ACTA ORTHOPAEDICA SCANDINAVICA
SUPPLEMENTUM NO. XIV (14)

STUDIES ON HIBBS' SPINE FUSION IN THE TREATMENT OF SCOLIOSIS

By

BJARNI JÓNSSON

EJNAR MUNKSGAARD . COPENHAGEN 1953

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FOREWORD

In 1947 and 1948 I held a fellowship at the New York Orthopedic Dispensary and Hospital. During my stay I became interested in the surgical treatment of scoliosis, especially since the non-operative treatment of this disease does not offer too bright prospects.

The material covers the seven year period from 1936 to 1942, five years being considered the minimum follow-up time necessary to judge the results.

I copied the Roentgenograms myself, some of them I found impossible to copy and some of my copies did not give usable prints, therefore not all of the case histories are accompanied by pre- and post-operative X-ray copies.

I am greatly indebted to Dr. Alan DeForest Smith, Surgeon in Chief of the New York Orthopedic Dispensary and Hospital, for making it possible for me to do this study, by granting me a fellowship and permitting me to make use of the material of his hospital.

I also wish to extend my thanks to Mr. Thorbjörn Sigurgeirsson, mag. scient., of the Technological Department of the University in Reykjavík for his help in determining the accuracy of the method used for measuring the curves. Thanks is also due to Dr. Robert Blatter of the U.S. Air Base in Keflavík and Mr. M. Lorimer Moe of the U.S. Information Service in Reykjavík who have both critically perused the manuscript as regards the language.

Grateful acknowledgement is due to Sáttmálasjóður for financial aid.

And last but not least I want to thank my wife, who besides doing the secretarial work has been a never tiring linguistic aid.

Reykjavík, June 1953. BJARNI JÓNSSON

ETIOLOGY

The term scoliosis or lateral curvature of the spine is purely descriptive and does not represent an etiological entity. A few groups of scoliosis have a well defined etiology, but in by far the largest group the causes are obscure.

Muscular imbalance is the causative factor in one group, infantile paralysis being the cause in the vast majority of those cases. The weakened or paralyzed muscles causing the deformity usually are those of the abdomen or the muscles of the spine itself. Paralyzed intercostal muscles or the muscles of the shoulder girdle may also play a rôle.

Multiple intercostal neurectomy described by Alexander and devised to give rest to a tuberculous lung by paralyzing a portion of the respiratory muscles causes a deviation of spine (Bisgard (12)). Torticollis likewise causes a cervico-dorsal curvature.

Krukenberg (108) sees in the unequal strength of both psoas major muscles a causative factor in the production of a lumbar scoliosis. If, he says, the psoas major muscle is not looked upon as a motor for the hip, but the trochanter minor is presumed to be a fixed point, the function of this muscle is one of stabilizing the lumbar column. Should one of these muscles be appreciably stronger than the other, then the lumbar spine will be pulled towards that side (Fig. 5).

The paralytic scoliosis usually manifests itself first when the patients get out of bed and again assume the upright position, implying that the gravitational force is a factor of importance in producing the lateral curvature.

Spastics may occasionally develop scoliosis although the theory of Guerin was discarded long ago. His theory, that the universal cause of lateral curvature was spastic contraction in certain muscles or groups of muscles due to some lesion in the central nervous system, was quite popular for some time about the middle of the last century (Behrend (7, 8), Guerin (70, 71, 72), Heine (81), Klein (101)) although it had an eloquent adversary in Bouvier (17).

Brick carriers' scoliosis (Golebiewski (66)) is of interest in so far as it

shows that muscular imbalance does not necessarily have to originate in a loss of power, but can as well be caused by hypertrophy of certain muscles.

Golebiewski's brick carriers carried bricks up ladders in buildings under construction. They were paid according to the number of bricks carried and through hard work they could earn a good living. They carried the bricks always on the left shoulder and gradually developed a marked hypertrophy of the muscles of the left shoulder girdle and hemithorax and, along with it, a left convex dorsal scoliosis.

Wullstein (183) produced structural scoliosis in growing dogs, which he kept in a scoliotic position by means of bandages for five to six months beginning at the seventh to the thirteenth week; Haas (77) attained the same end by injuring surgically the cartilaginous plates in the lumbar vertebrae in dogs.

Congenital scoliosis may be due to malformations of one or more vertebrae or to some defect in the muscular or nervous system.

The causes most often seen, are underdevelopment of one side of one or more vertebrae, including hemivertebrae, where one half is entirely absent (Compere (32), Gonzales (67), Jaroschy (94), von Lackum & Smith (111), Royle (147)). These cases usually show rather sharp curves in contrast with the smooth curves common in idiopathic cases.

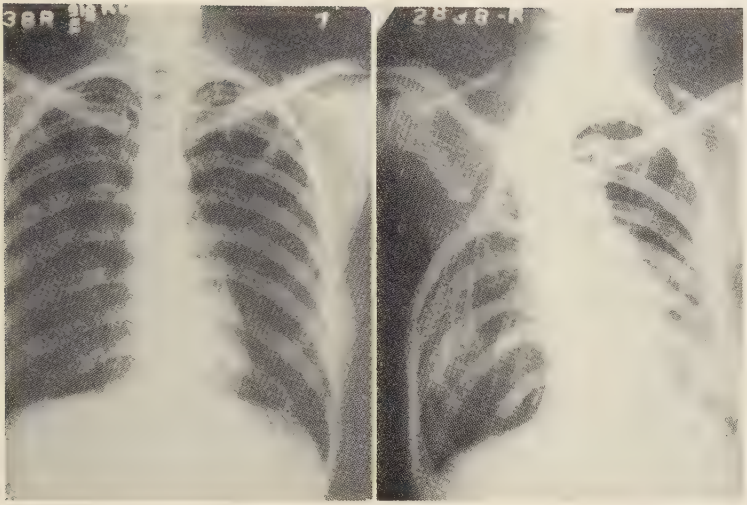
Thoracogenic scoliosis is caused by factors affecting the thoracic cage or the chest organs.

An empyema may cause scar formation of the pleura and this scar tissue tends to retract, approximating and immobilizing the ribs on the diseased side thereby producing a lateral curvature with the convexity pointing towards the healthy side (Gurd (74), Selig & Arnheim (158)).

Pleurisy may also cause a retraction that works the same way (Laennec (112), von Rokitansky (146), Bisgard (12, 13)). As a matter of fact, the mode of producing the deformity is the same, a retraction of a pleural scar, whether this scar formation is produced by a pyogenic organism or something else.

Occasionally, in chronic tuberculosis of the lung where there are massive adhesions along the chest wall and the vertebral gutter, a retraction of the fibrous lung may pull the dorsal spine out of line towards the diseased lung (Sauerbruch (150), Bisgard (12)). The most common thoracogenic scoliosis, however, is the lateral curvature which follows thoracoplasty.

It is a well established fact, that nearly all patients on whom a thoracoplasty has been performed develop a lateral curvature of the spine and that this curvature is convex towards the operated side (Fig. 1) (Von Beust (10), Cleveland (30), Wenger (172), Wenger & Herman (173), Bisgard (12)). These curvatures are usually of a moderate or mild degree,



A B

Fig. 1.
Post thoracoplasty curvature. (Courtesy Dr. J. M. Chamberlain, New York).

but can occasionally cause a most severe deformity, especially in young patients. Cleveland (30) has reported six cases of post-thoracoplasty scoliosis in children. Five of these patients averaged fourteen years. One year after the operation they had a 25 to 30 degrees curvature. The sixth patient was twelve years old and this child developed a 74 degrees curve during two years following the operation.

Wenger & Herman (173) in reviewing 256 cases of thoracoplasty came to the conclusion that the costo-transversal and intertransversal ligaments were of major importance in holding the spine straight. They attribute the development of thoracoplasty scoliosis to the removal of the transverse processes, thereby destroying these ligaments. "In not one instance, in our series," they say, "was there a severe or serious scoliosis in the presence of intact transverse processes." Further, "in the majority of the cases which had escaped a spinal deformity, the transverse processes were intact". Practically the same opinion of the importance of the ligaments was uttered by Bouvier (17) in his denouncement of the Guerin procedure.

Sciatica, whether it is due to a herniated nucleus pulposus or other causes, often produces some lateral deviation of the lumbar spine through a protective contracture of the muscles; when the sciatica is cured, the spine straightens out again. These deviations rarely reach a marked degree.

The same protective muscle action might be the cause of the nephrogenic scoliosis described by Blumensaat & Nestman (15). Goecke (65) and Johow (96) describe scoliosis having probably a traumatic origin and

Frosch (58) reports a case of an apparently benign radioopaque tumor ankylosing L_2–L_4 accompanied by a lateral curvature.

Allen, discussing Hibbs' paper (86), and Krukenberg (108) mention the retraction of extensive scars as leading to a scoliotic deformity.

Various other causes may occasionally produce a scoliosis.

The etiology of the largest group of scoliosis, however, is still an unsolved problem. Through the years numerous theories have been advanced to explain this condition, theories more or less substantiated by facts, usually less. Some of them have been purely speculative.

Many authors name rickets, either infantile or the late variety, as the only or main responsible cause (Casse (26), Engelmann (39), Herz (83), Lange (116), Peckham (137), Spitzy (163), Spitzy & Lange (164), von Rokitansky (146), Fromme (57)). None of them offers proof of his hypothesis. It is obvious that in a general disease like rickets the vertebral column is bound to be affected like other parts of the skeletal system. But it is by no means obvious that softness of the vertebrae should manifest itself in the form of a lateral curvature. On the contrary, it is a well known fact that, if the spine of a rachitic child deviates from the normal shape, this deviation takes the form of a kyphosis. In the infant this kyphosis is localized at the lower dorsal and upper lumbar spine or is entirely in the lumbar vertebrae.

In osteomalacia and in senility, when the osseous system grows weaker, this weakness manifests itself in increased kyphosis and not in a deviation from the midline.

In localities where rickets is prevalent, rachitic stigmata such as bow legs and Harrison's grooves are common and of course may be seen on many of the scoliotics. But then again many more with straight spines present these same stigmata. The rickets could then at the most be a contributing cause, if it has anything to do with the condition at all.

Herz (83) reports that rickets is very rare in New Zealand and likewise is scoliosis. In Iceland rickets is common, although usually mild (Dungal (35), Thoroddsen (168)), but severe scoliosis is of rare occurrence.

The usual age for scoliosis to develop is from about the eighth year to the cessation of the growth of the spine. The predominant age for rickets is early infancy.

In this material only two pat. had rachitic stigmata or a history of rickets and one of them had a flaccid paralysis of the left foot as well, probably due to poliomyelitis although there is no such history. This patient is accordingly classified as a paralytic scoliosis leaving a single one with rachitic stigmata in 170 cases of idiopathic scoliosis.

Klapp (100) sees the deforming cause in a general degeneration and weakness of connective tissue and supporting elements; Schanz (152, 153)

is of the opinion that excessive load and decreased resistance are imperative in producing the lateral curvature. This may be so, but the underlying cause of the general degeneration and the decreased resistance remains unexplained. Excessive work load certainly tends to increase a curve once formed, the scoliotic spine straightens out about 5 to 15 degrees on the average simply by lying down. On the other hand, compared with what happens in rickets, osteomalacia and senility, one would be inclined to think that excessive burden thrown on a spine would rather tend to increase the preexisting physiological kyphosis than to produce an entirely new curve in a spine that has no deviation from the midline.

Lorenz (123) speaks of the effect of asymmetrical burden. Usually no such history can be obtained. The scoliotic children have no history of being more asymmetrically burdened than other children in their environment. Of course they may carry their books always in the same hand or they may use one hand more than the other, but so, most likely, do all their companions without any harmful effect. Schulthess (156) is of the opinion that the long sitting hours in school constitute a menace to the spine, directly causing some of the milder deformities and increasing those already existing.

Meinert (133) advocates the theory that tight garments, such as corsets, cause the lateral curvature. The generation of to-day has hardly seen a laced corset outside a museum.

Von Finck (50, 51) sees in a spina bifida occulta the underlying cause for scoliosis. This condition is seen often in otherwise normal spines.

Erlacher (42) states that a distension of the nucleus pulposus must cause a scoliosis. If the nucleus pulposus is placed in a hypotonic solution such as water, it distends. But is there any likelihood for such osmotic phenomena to take place in the living organism?

Jaboulay (92, 93) attributes the curvature to a difference in length of the corresponding ribs on both sides, the ribs on the convex side being about one centimetre longer than those on the concave side.

Meyer (134) measured the length of the ribs in one case of severe right convex scoliosis. He found a difference of 0.2 to 0.9 centimetre in the length of the corresponding ribs on both sides. However, the upper ribs on the right side and the lower ones on the left side were longer than the matching ribs on the opposite side. The first ribs were of equal length on both sides.

Böhm (16) is of the opinion that the functional or mechanical factors are of secondary importance in the production of scoliosis. The real cause, he states, is of embryonic origin and is identical or closely related to the developmental anomaly that manifests itself in the numerical variation of the vertebrae.

In this material of 208 cases, numerical variation of the vertebrae was present in twenty-five, the most frequent being eleven thoracic and five lumbar vertebrae with twelve thoracic and six lumbar and thirteen thoracic and five lumbar also occurring. (Table 1).

Kozlovski (107) in fifty-four cases of scoliosis, found congenital deformities of L_4–L_5 in two thirds of these patients. He is of the opinion that

TABLE 1

Etiology	Number of cases	Numerical variation number	per cent
Idiopathic	170	21	12.35
Paralytic	30	3	10.00
Congenit.	6	1	16.67
Post. emp. & thoracoplasty	2	0	0
Total	208	25	12.02

deformities of the lowest lumbar vertebrae are an important etiological factor in the production of scoliosis.

Chronic underfeeding or malnutrition of the child during the first decade of life is suggested by Carey (25) as the insidious cause of idiopathic structural scoliosis. He states that scoliosis is a spinal sign of the imbalance of muscle and bone growth of the motor system of the back and is not a specific disease entity. The kind and degree of scoliosis are dependent on the extent of the imbalance caused by the weakening and possible paralysis of multiple combinations and permutations of the muscle groups of the body as a whole. He says further, that in chronic infantile inanition and malnutrition there is a decrease in muscle weight and a persistence in skeletal growth in length. The muscles do not degenerate uniformly. This asymmetrical local muscular atrophy and localized muscular weakness or paralysis of the undernourished child are assumed by him to be more pronounced in girls than boys.

The patients in this material have on the whole, been well nourished and well developed and there is nothing to suggest that they have not been so all their lives. Scoliotics do not come only from classes or localities where a lack of adequate food might be expected. They are found as well where there is an abundance. The case histories do not show that they have been sickly during infancy or early childhood.

More than sixty years ago Ketch (99), on reviewing the scoliosis material of the New York Orthopedic Dispensary, came to the same con-

clusion, "the patients have generally been healthy children and at the time of examination were in good general condition".

Whitman, A. (174) did not see undernourishment or poor muscular tone in his patients with scoliosis.

Twelve out of 170 patients with idiopathic scoliosis in this material were either undernourished or underdeveloped or both, but none of them seriously so, when they entered the hospital.

That does not prove, however, that these patients have always been undernourished any more than the well being of the other 158 patients proves that they have always been well fed. These findings suggest that malnutrition does not play an important rôle in the formation of the lateral curvature, if it has anything to do with it at all.

Faber (43) states that there is undoubtedly a hereditary factor involved in the production of the socalled rachitic scoliosis. On the other hand in congenital malformations of the vertebral column, he could find no such hereditary factor. In 170 idiopathic cases, twenty-one patients had one or more close relatives who were afflicted with the same condition. One of these was known to have a poliocurve and two of these patients were sisters. That leaves nineteen families with more than one member scoliotic.

In fifty-five cases, occurrence of scoliosis in the family was denied; in the remaining ninety-five cases there was no information.

Of thirty paralytic cases, one patient had a sister with a lateral curvature. Three denied any scoliosis in the family and in the remaining twenty-six there was no information about similar conditions in the family.

In the six congenital cases, scoliosis was denied to have occurred in other family members in two cases and in the remaining four there was no information.

The occurrence of curvature of the spine amongst other members of the above mentioned nineteen families is as follows:

One parent	4 cases
both parents	1
one sibling	5
two siblings	1
parent and sibling	3
aunts, uncles or cousins	4
mother and four out of nine siblings	1

McLennan (128) states that unequality of growth between the anterior and posterior elements of the vertebrae, the bodies and the intervertebral discs on one hand and the laminae on the other, causes the spine to bend laterally.

Bisgard & Musselman (14) see a probable cause for idiopathic scoliosis in a unilateral retardation of the growth of one or more vertebrae, possibly caused by epiphysitis, epiphyseodystrophy or a congenital abnormality of the cartilage.

That growth is an important factor in the production of scoliosis, is reported by Risser & Ferguson (144). In studying 296 cases of untreated scoliosis, they arrived at the following conclusions:

1) "Increase in curvature in scoliosis ceases when vertebral growth stops"
2) "Rapidity of increase of curvature corresponds to rapidity of growth"
3) "The relation of increase of curvature to growth is not materially influenced by the etiology of the curve".

The exact mode of influence of the growth on the curvature, however, remains unexplained.

Dyes (36) reports a change in the epiphyseal plate of scoliotic spines on the Roentgenogram, the plates being of a normal thickness on the convex side but conspicuously dense, whereas on the concave side they are thinner or may be entirely absent. But, as he points out, it cannot be determined from the X-ray films whether this is a primary or a secondary phenomenon.

Hibbs et al (88) advance the theory that the majority of idiopathic scoliosis may be caused by instrinsic muscle imbalance due to infantile paralysis, although undetected, the curvature being the only evidence of this fact.

It is evident that any major imbalance of the intrinsic musculature may, or must, lead to a curvature of the spine. The question, however, of whether such an imbalance is the actual cause of the common idiopathic scoliosis must be left unanswered for the time being, there existing at present no clinical method of evaluating the strength of a single intrinsic muscle or of anyone of their vast number of combinations.

The higher incidence of scoliosis in the female sex makes a general disease like poliomyelitis or rickets a rather unlikely cause for scoliosis, unless some additional causative factor is introduced.

PATHOLOGY

The scoliotic deformity is composed of several factors.

When looked at from behind, a normal spine is straight and perpendicular to a horizontal plane of support. In a scoliotic the spine curves, causing the vertebrae to deviate more or less from the straight line, the deviation being greatest at the apex of the curve.

There is never one curve alone; adjoining segments curve in opposite directions in an endeavour to maintain the balance of the trunk, to keep the center of gravity of the body over the area of support and to keep the eyes in a horizontal plane.

If only one segment of the spine curved, the other remaining in the straight position, the trunk would bend to one side (Fig. 2 A). If we assume that the primary curve cannot be straightened out voluntarily, the upper and lower segments being mobile, the restoration of balance will be effected by the curving of these segments (Fig. 2 B). If the adjoining segments cannot afford enough compensation the head will not be held in the midline, and the trunk will be shifted to one side (Fig. 2 C). In these cases the pelvis may be tilted to regain body balance (Fig. 2 D). This tilt of the pelvis must not be confused with the pelvic tilt caused by a short leg. In the case of a pelvic tilt due to unequal length of the lower extremities, the cause and effect is reversed. Here a curvature of the spine is induced to compensate the pelvic obliquity.

Along with the lateral curvature, there is usually a rotation of the vertebral column increasing with the severity of the curve, but not necessarily proportionate to the degree of the lateral curve.

As the spinal column grows, changes take place in the individual vertebrae according to Wolff's (180) law. The vertebrae become twisted so that not only the whole curved segment becomes rotated but also each vertebra, this deformity being most pronounced at the apex of the curve. Besides being twisted the vertebrae become wedgeshaped, shorter on the concave side. This deformity is also most pronounced at the apex of the curve, the end vertebrae being of equal height on both sides. Albert (2) is of the opinion that only the top vertebra is wedgeshaped, with the bodies

of the adjoining vertebrae slightly diamond shaped, their sides being oblique, but the upper and lower surfaces parallel. The intervertebral discs being thinner on the concave side and thicker on the convex.

Lehmann-Facius (119) is of the opinion that the wedging of the elastic intervertebral discs is the primary phenomenon, the wedging of the vertebrae being secondarily caused by the growing vertebral bodies at-

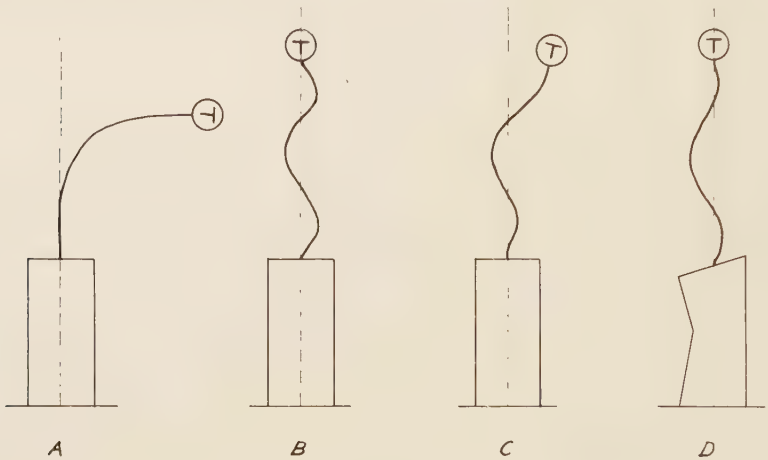


Fig. 2.

tempting to conform to the altered shape of the discs. However, a retardation of growth, through pressure, on the concave side might also play a rôle. The ligaments on the concave side become shorter, whereas they stretch on the convex side. When these changes have taken place we have the "structural scoliosis".

The rib deformity follows the rotation of the vertebrae. There is a posterior bulging of the ribs on the convex side and an anterior fullness on the opposite side. Posteriorly, on the concave side, the ribs flatten out (Fig. 3). The posterior ends of the ribs are firmly attached to the transverse processes. If their anterior ends were free to move, the ribcage would rotate with the vertebral column probably without much change in the form of the ribs. However, in front the ribs are securely fastened to the sternum which does not move, but, as Calvé (23) has pointed out, keeps its position in the midline. Therefore, when the vertebrae rotate and along with them the posterior ends of the ribs, the ribs must alter their shape, so that a transverse section of the thorax instead of being roughly circular, becomes an oval with the longest diameter being oblique. This deformity is most pronounced when the patient bends forwards, in fact when the rib deformity is slight it may escape notice when the patient stands erect, especially in obese patients and only become evident on bending forward.

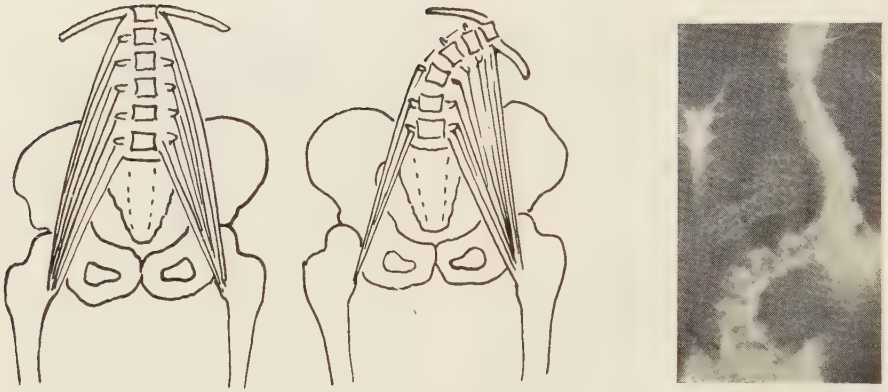
Fig. 3.
Pronounced rib deformity and prominence of left hip.

Fig. 4.
Prominence of left hip without much rib deformity.

Lovett (124) looked upon the spine as a flexible rod and assumed that it followed the same mechanical laws. "A straight flexible rod can be bent in one plane without twisting but if such a rod be bent in another plane it must twist. A fixed combination of twisting and side bending exists for every position".

To prove this hypothesis, a certain number of scoliotic spines would have to be measured accurately as regards the antero-posterior bending, the lateral curve and the rotation. I do not know of any such measurements having been made. On the other hand, there can be a considerable difference in the rib deformity accompanying two scolioses of the same severity in the same segment of the spine with no clinically appreciable difference in the antero-posterior curve. As the rib deformity depends primarily upon the rotation of the vertebrae to which the ribs are attached, this would mean that there can be several degrees of rotation for any given lateral curve. Abbott (1) states ". . . that the spine can be bent laterally and that rotation can be made easily at the same time in either direction, that the spine can be bent to one side and no rotation take place; or that rotation can be made without any lateral bending". Carey (25) said that there is no direct correlation between the rotary and the lateral deviation components of the rotated laterally curved spine.

Bisgard (12, 13) pointed out that retraction of a pleural scar bends the spine laterally without causing rotation deformity both in man and in the experimental animal.



A B C

Fig. 5.
A and B, effect of imbalance of the psoas muscles (redrawn after Krukenberg).
C. Krukenberg type of scoliosis.

The elevation of one shoulder depends upon the failure of an upper curve to compensate, except when the primary curve includes the uppermost dorsal vertebrae, then the elevation is caused by the main curve itself. Similarly a prominent hip may be caused by the failure of a lower curve to compensate. It is always present in some degree when the primary curve extends well into the lumbar spine (Fig. 4) and is most pronounced when there is a list of the trunk to the opposite side.

When the primary curve includes a long segment of the spine, there is usually more or less displacement of the trunk towards the convexity of the curve. The same is the case when the compensatory curves cannot afford enough compensation. This shift of the trunk is particularly pronounced in the type of dorso-lumbar curves which Krukenberg (109) considered due to imbalance of the psoas muscles (Fig. 5).

The deformity of the spine and the rib cage, causes certain changes of the internal organs, particularly of the lungs. The narrowing of the thorax following the rib deformity diminishes the space occupied by the lungs and the change in the form of the ribs and the intercostal spaces decreases the respiratory excursions. Thus the respiration is embarrassed and in cases of respiratory infections the cleaning of the bronchial tree is more difficult than in a thorax which is normal in shape and function. Bachmann (4) reviewing 276 cases of thoracic deformity, seventy-nine previously reported and 197 of the Pathological Institute in Breslau, found pneumonia in 60 per cent, emphysema in 46 per cent, bronchitis in 41.6 per cent, atelectasis in 31.2 per cent and bronchiectasis in 6.1 per cent.

Patients with severe scoliosis are usually rather short of breath and have little respiratory reserve. Their vital capacity is low (Flagstad & Koll-

mann (52)). The right side of the heart has to work against increased resistance causing hypertrophy of the right ventricle with ultimate dilatation and cardiac failure. Once severe cardiac symptoms develop they usually progress rapidly to a fatal outcome.

Bachmann (4) in 154 cases of thoracic deformities, in which an exact post mortem cardiac diagnosis was available, found eighty-seven with hypertrophy of the right ventricle with or without dilatation.

Chapman et al (27) reported forty-five out of sixty-nine cases with hypertrophy and dilatation of the right ventricle. They stated that symptoms usually appear within a few years after the deformity reaches its maximum. The average age at death of seventy-nine patients was thirty years.

Kerwin (98) reported five cases of pulmono-cardiac failure due to spinal deformity, the average age at death being fifty-three years which is unusually high. Hypertrophy and dilatation of the right ventricle were constant pathological findings.

Lam & McClure (113) reported one case of an operative decompression of the heart in a severe scoliosis. The patient, a thirty-four year old female, complained of dyspnea, palpitations and excessive fatigue. The distance between the spinal column and the sternum was very short. The operation consisted of severing the cartilaginous ends of the ribs at the left side of the sternum, rotating the sternum and reattaching the fifth rib to the sternal attachment of the sixth. Two years later the patient was working full time and had no complaints. In this case a direct pressure on the heart seems to have been the cause of the cardiac embarrassment.

After the lungs, the liver is the internal organ showing the greatest deformity (Bachmann (4)). No evidence of impairment of the function of the liver due to this deformity is reported.

The pelvis is usually not distorted or only to a slight degree as a consequence of a lateral curve of the spine. However, in cases of rickets or osteomalacia running concurrently with a scoliosis, the pelvis may be severely deformed, but this deformity is due to the general disease and not to the curvature of the spine per se.

Györy (75) stated that a deformity of the pelvis sometimes accompanying scoliosis may be so severe that a normal labour may be impossible, but he also said that the most severe deformities occur in cases of rickets. He further pointed out that complications from the lungs or heart are apt to occur in labouring scoliotic women, and that abnormal positions of the fetus are more common.

Of the 107 female patients, followed for five years or more after operation, fifteen had married and six of them had had seven children. The pregnancy and labour had been normal in every case. Besides that, one

patient (No. 219793) who was operated on at the age of thirty-six, had had children before surgery was done. There is no history of her pregnancies or labours.

Occasionally a compression of the spinal cord may develop, resulting in spastic paralysis and sensory disturbances of the lower extremities (Jaroschy (94, 95), Kleinberg (104), McKenzie (127), Ridlon (142), Elmslie (38), Lehrnbecher (120)). The usual time of occurrence of neurological signs is during adolescence and the period of rapid growth, although this need not always be the case. One of Jaroschy's five cases was twenty-eight years old (95) and Kleinberg's case (104) was only nine years of age.

Heyman (84), in 1937, said that twenty-eight cases had been reported, 60 per cent being associated with a long standing idiopathic scoliosis and 40 per cent with severe paralytic curves. The apex of the curve was at or above the mid-dorsal region.

In 1941, Ruhlin & Albert (148) reported seven cases with spinal cord involvement. In each instance, the scoliosis was of a severe type with the exception of one which was considered moderate but which was associated with a kyphosis.

Five of the cases were treated by laminectomy, four improved. The findings at the time of operation were torsion of the cord in four cases and direct pressure on the cord in one. The direct pressure was from a bony ledge and not from direct pressure by a vertebra.

Of Jaroschy's five cases, four were treated successfully with laminectomy, one was not submitted to operation.

McKenzie's case was completely relieved by laminectomy. One of Elmslie's cases was treated by laminectomy without result. He later improved some by traction. Lehrnbecher's case was also treated by traction with moderate success. Apparently none of the cases had a spinal fusion performed.

As is the case in other deformities, pain is a symptom of rather rare occurrence in the young scoliotic patients. The pain in a deformed hip or a talipes equinovarus increases with advancing age. The oldest patients in this series came to the clinic to seek relief of pain in the back. The fatigue sometimes complained of may be either localized in the back or of a general nature; the localized fatigue being caused by an insufficiency of the trunk and spinal musculature and the generalized fatigue probably being due to an impairment of function of the respiratory and circulatory systems. The mild and moderate cases of scoliosis do not seem to have much effect on these systems but in the severest cases a pulmono-cardiac failure is a frequent complication. The life expectancy of these patients is short and they are much handicapped in their physical activities.

According to Risser & Ferguson (144), the increase of a lateral curva-

ture stops at the cessation of vertebral growth, regardless of the etiology of the curve. This is the general rule and statements to the contrary by Kleinberg (102), who has seen scoliotic deformity increase during adult life, and by Colonna & vom Saal (32), who have seen cases of paralytic curves increase after cessation of vertebral growth, are exceptions from the rule. Colonna & vom Saal also state that they have not seen idiopathic scoliosis increase after the growth had stopped.

The prognosis of a given case of scoliosis cannot be ascertained by a single examination. Every case should be followed closely and Roentgenograms made repeatedly, especially during the period of rapid growth, so that active therapy can be instituted if the deformity shows progression.

SURGICAL PROCEDURES

During the last hundred years various procedures have been tried to ameliorate the condition of the hunchback.

Basically these tentamens can be divided into three major groups:

1) Operations on the soft parts,
2) operations on the ribs,
3) operations on the spine.

In the fourth decade of the last century Guerin (70, 71), probably inspired by the good results of Strohmeyer's tenotomies, advocated myotomies of various muscles of the back. He claimed that these operations, combined with the usual orthopedic therapy of that time, yielded good results. This procedure seems to have enjoyed a considerable popularity for some time (Childs (28), Heine (81), Behrend (8), Klein (101), Laycock (117)). Its main adversary was Bouvier (17). He showed by experiments on cadavers that myotomy alone was not sufficient to allow the spine to straighten out. Not until the ligaments were severed could the deformity be corrected.

In 1844 Malgaigne (129) published a follow-up study of twenty-four patients who had been treated by the Guerin method and found that none had been completely cured and only six had received a partial benefit from the operation.

In 1877 Sayre (151) reported a good correction of a severe right dorsal curve in a nineteen year old male by dividing the entire latissimus.

In 1924 Loeffler (122) described a method of dividing the erector trunci, which he had used in more than 200 cases. The after treatment consisted of traction and plaster jacket. He saw some improvement in his patients.

Gruca (68) in 1925 reported eighteen cases treated by Loeffler's method and stated that all but one were visibly improved.

Plagemann (139) in 1925 reported eight cases of myotomy of the erector trunci. The immediate results were good but after a few years they were no longer satisfactory.

In 1917 Krukenberg (108) described a myotomy of the psoas major muscle for lumbar scoliosis. He divided the muscle on the concave side of the curvature, assuming that this muscle pulls the lumbar spine out of line if it is stronger than the psoas on the other side (Fig. 5). In a later publication (109) he proposed an additional tenotomy of the obliquus externus muscle in some cases.

Johow (96) reported one case of lumbar scoliosis treated by Krukenberg's operation. An eight year old child had pain in the lumbar region and appendicitis was suspected. The vermiform process was found adherent to the psoas muscle and was removed. The pain subsided, the curvature remained. After division of the psoas muscle, the spine straightened out. Schultz (157) reported twenty-three cases treated by the Krukenberg method; that of myotomy of the psoas muscle on the side of the lumbar concavity and division of the obliquus ext. aponevrosis on the other side. In seven cases there was only slight improvement, the remaining being satisfactory.

Transplantation of muscles or fascial straps has been tried in several cases. Krukenberg (110) and later Girard (64) transplanted the origin of the hamstring muscles from the tuber ischii to the symphysis to correct a pelvic obliquity and thereby to control the spinal curvature.

Schepelman (155) loosened the long extensor muscles on the concave side of the curvature and pulled the musclebundle over the spinous processes and fastened it on the convex side. Then he pulled the transverse muscles on the concave side as far as possible over to the opposite side where he fastened them securely. At the same time the corresponding musculature on the convex side was transposed one to three fingerbreadths laterally.

Plagemann (139) and Haas (78) changed the insertions of the trunk muscles on the pelvis and in addition used fascial straps to stabilize the trunk.

Lowmann (125) used fascial straps to substitute paralyzed abdominal muscles.

Colonna & vom Saal (32) state, "that fascial straps give a feeling of security to the patient and have a stabilizing effect upon the remaining trunk muscles and pelvis".

Extensive scars tend to retract and may, if they are so located, cause a lateral deviation of the spine. It has been proposed to produce a scar on the convex side of a scoliotic and let its retraction take care of a curvature (Allen discussing Hibbs' paper (86)). This procedure has been undertaken not only in days gone by (Giertsen (63)) but also in modern times (Chlumský (29)).

Plagemann (138, 140) fastened both scapulae together with silk sutures

supposing that over-distended back musculature might regain its power and straighten the spine.

In severe scoliosis, the most deforming factor is the posterior rib prominence. It is therefore no wonder that surgeons relatively early attacked the ribs, both to lessen the rib deformity itself and to correct the spinal curvature.

In 1889 von Volkmann (171) did the first rib resection to lessen this deformity. He resected a part of the three lowest ribs on the convex side. In a second case done a little later he resected pieces of the seven lowest ribs. The after treatment consisted of traction and application of Sayre's plaster jacket.

In the next few years Casse (26) (1893), Hoffa (90) (1895) and Tietze (169) (1897) each did a rib resection on one case. A later report on these cases has not been found from the hand of the authors so that it does not seem likely that they have found the results so gratifying that they have used the procedure in many cases. Schanz, who was Hoffa's assistant at this operation, reported to the German Orthopedic Congress in 1914 that the patient had been extremely shocked and after the operation Hoffa had said, "once and never again". (Discussion of Maas paper (126)).

Later Gaudier (61), Gaudier & Swynghedaw (62) and Mauclaire (132) tried the rib resection. Jaboulay (92, 93) recommended the rib resection on the convex side and in some cases he advocated his desternalization, that is severing the cartilaginous ends of the ribs thereby devoiding them of their anterior fixed points. He claimed that the thorax flattened out by this procedure and the rib deformity decreased.

In 1902 Hoke (91) resected ribs on both sides aiming at increased mobility of the spine. Wreden (181, 182) later used bilateral rib resection to mobilize the spine and, after two months traction treatment, fused the spine with the help of a Lane's plate placed on the concave side of the spinous processes and a tibia graft on the convex side.

Buchman (19) and Einarsson (37) have each reported a case of rib resection in combination with spine fusion to increase the cosmetic result.

Whitman, A. (176, 177), Epstein (40, 41), Colonna & vom Saal (32), Bickel et al (11) have used resected pieces of ribs, either alone as grafts to fuse the spine, or in combination with other types of fusion.

Maas (126) resected five ribs on the concave side in two cases, a four and an eight year old child, with the intention of increasing the mobility of the spine. Immediately after the operation the mobility was considerably greater but eight days later the spine was nearly as stiff as before.

Hoessly (89) and Sauerbruch (150) both resected ribs on the concave side, having observed that a lateral curvature convex towards the diseased

side frequently followed thoracoplasty. Hoessly has rejected the use of convex rib resection, stating that it is followed by a great reduction of the vital capacity.

Sauerbruch (150) tried in one case to wire the ribs on the convex side together with copper wire after he had resected the third to the seventh rib inclusive on the concave side. The immediate result was striking but it was not maintained. Two ribs fractured, some of the wire cut through and some was expelled by suppuration. He also tried bilateral rib resection in one case.

Lange (114) reported one case operated on by Sauerbruch, that of a rib resection on the concave side and stated that six months later the curvature was essentially unchanged, but the posture was somewhat better.

Fenkner (44, 45) used rib resection on the concave side in combination with Krukenberg's psoas myotomy. In a later publication (46) he reported that of his six cases one had remained good, one was about stationary, at least not much worse and one was continually getting worse. Three were not seen later but one of them, an eighteen year old male, was said to be stationary. The other five patients were from five to ten years old at the time of the operation.

Gurd (74) reported one case of postempyema scoliosis which was overcorrected by a resection of the second to the tenth rib on the concave side.

Bergmann (9) reported one case, treated by Frey with resection of the fifth to the tenth rib on the concave side. On the convex side the fifth to the eleventh rib were approximated and fastened together by means of metal bands. At a reexamination three years later, the curvature had increased.

Vogel (170) tried to correct a curvature in a nine year old boy by fastening two ribs together on the convex side. The fixation, however, was so painful that the threads soon had to be removed.

Guradze (73) in one case tried to correct the asymmetry of the thorax by applying a continuous traction on one rib on the concave side. The rib became necrotic at the site of the traction without any bad effect on the patient but apparently without any correction of the deformity either.

Wittek (179) in the case of a thirteen year old girl with a left lumbar scoliosis, excavated the left half of L_4. At an examination two years later the spine was straight. In another case he tried to excavate a hemivertebra between D_3 and D_4 but gave it up because of technical difficulties.

McLennan (128) stated that he excavated the body of the vertebra at the top of the curve and sometimes the next higher and lower one. He published no figures but is satisfied with the results.

Royle (147) in one case of a two and one half year old girl, removed an accessory hemivertebra between L_1 and L_2.

Compere (33) removed hemivertebrae in two children in their second year. In one case the vertebrae in question were D_{11} and L_1 and in the other L_1. He fused both spines.

Frey (56) removed the body of the D_9 in a twelve year old girl with a right curvature D_4–D_9–D_{12}. Photo and X-ray eleven weeks later show excellent correction.

Smith reports ten cases operated on for removal of vertebral bodies by von Lackum (von Lackum & Smith (111)), five with curvatures caused by hemivertebrae and five with ordinary scoliosis. In the lumbar region the operation was comparatively easy, in the dorsal area of the spine the difficulty of exposure and severity of hemorrhage made the operation so difficult as to be impracticable. The removal of the vertebrae was followed by a Hibbs spinal fusion. "The results of the operations in the ten cases may be summarized as follows: Two patients with hemivertebrae between the third and fourth lumbar were corrected to the point where their spines were straight and there was no apparent curvature. In the first the curve was reduced from 31 to 9 degrees and in the second it was overcorrected from a left curve of 37 degrees to a right curve of 7 degrees. One twenty-two year old patient with a marked left lumbar curve was corrected from 30 degrees to 6 degrees by removal of portions of first and second lumbar bodies. Two other patients obtained substantial reductions in their lateral curves, but this was offset by the occurrence of a kyphosis and failure of fusion of the spine at the site of operation. The other cases were either not corrected beyond the condition before operation or subsequently progressed still further. These were all dorsal curves and the failures are attributable to inability to complete the removal of the body or portion of the body, because of hemorrhage. One patient died of shock. The average period of observation after operation was four and one half years."

Pseudarthrosis, or a defect in the spine fusion at the site of operation occurred in six of the nine cases.

Wenger (172) advocated transversectomy on the concave side to correct primary scoliosis and Radulescu (141) recommended costo-transversectomy of four to six ribs.

Baeyer (5) observed that the articulating processes are longer on the convex than those on the concave side in a scoliotic spine and constitute an obstacle to the correction of the curvature. He therefore removed the articulating processes on the convex side of the lumbar spine to correct the lower curvature assuming that the compensatory forces will take care of the upper curve later.

The most widely used procedures, however, in the surgical treatment of scoliosis are the ankylosing operations of the spine. A forerunner of these operations is Hadra's (79) experiment to immobilize adjacent vertebrae by wiring together their spinous processes, described in 1891.

In 1924 Hanausek (80) employed a similar procedure in one case of a lateral curvature. He fastened together adjacent transverse processes on the convex side with silk. He intended to keep the convex side of the vertebrae under continous pressure assuming that this pressure would inhibit the growth on the convex side, leaving the other half free to develop.

Another method of immobilizing the spine was attempted by Lange, F. (115). In 1902 he placed steel rods four millimetres thick and ten centimetres long on both sides of the spinous processes. In a few months abscess formation necessitated removal. In 1908 he used tin coated steel rods and in 1920 celluloid rods. Baeyer (6) recommended this type of immobilization.

To-day the prevalent surgical treatment of the lateral curvature of the spine is the ankylosing operation after the deformity has been corrected as much as possible. There have been numerous procedures in use to attain this end. Basically, however, they can be divided into two main groups:

1) The Albee method which accomplishes the immobilization by means of a solid graft of autogenous bone placed in contact with the spinous processes.
2) The Hibbs method, ankylosing the articulations between the vertebrae and fusing the posterior elements of the spine into a solid plaque of bone by cutting the spinous processes and posterior parts of the laminae into bone chips which are placed over the fusion area.

The first spine fusion operations for scoliosis were done in 1913. Galloway (59) reported three cases of paralytic scoliosis operated on by the Albee method. The first case was done in July. He states that Kidner had done one case ten days earlier.

Forbes (53, 54) reported that the first spinal fusion for scoliosis in Montreal was done in 1913. His method consists of gauging of the spinous processes and laminae, bridging the interspaces between the laminae with the bone chips.

Whitman, R. (178) in 1921 reported twelve cases operated on by this method and Tavernier (165) used practically the same technique. Kasakevič (97) in 1926 described essentially the same procedure, the only difference being that he cuts the spinous processes in two halves instead of smaller chips.

Henry & Geist (82) and Colonna & vom Saal (32) use additional bone taken from the tibia or the ilium of the patients.

Vom Saal (149) continues the subperiosteal stripping out the transverse processes. An osteotome is driven through the base of the transverse process which is lifted with a clamp and the under-surface stripped. Then chips from the laminae, spinous processes and transverse processes are laid over the fusion area which is unusually broad. The author uses this method only in the thoracic part of the spine, where the ribs protect the underlying structures when the transverse processes are removed.

Bureau (20) reported eighteen cases of Albee fusion for scoliosis, twelve had a follow-up of more than one year. Of these, eight were classified as excellent, three as fair and one as poor. In the last case the deformity was progressing.

Gauchet (60) reported one case, a fifteen year old female; examined one and one half year after the operation, the deformity was stationary.

Camera (24) in one case, a six year old child with paralytic scoliosis, fused the spine from D_3 to L_3 in two stages.

Hoessly (89) reported one case, a six year old boy, whose deformity had not increased eighteen months after operation.

Schede (154) reported four cases all female:

1) Fifteen year old. One year after operation, the curvature was stationary, no complaints.
2) Nine year old. Immediate result good, but later the deformity increased.
3) Sixteen year old. Slight improvement.
4) Fourteen year old dwarf. Died three days after operation from heart failure.

Morvau (136) reported three cases, one fifteen year old female and two sixteen year old males. The patients were seen four, three and one and one half years later respectively. There was absence of pain and no increase in the curvature.

Rocher & Pouyanne (145) fused one case, a twenty-five year old male for painful scoliosis. On examination two and one half years later, he was found to be free of pain and working full time.

Diamant-Berger (34) mobilized the muscles on one side, cut the spinous processes at their bases and placed a tibial graft in the bed thus prepared.

Tavernier (165, 166) found that an Albee graft in a growing individual tends to increase the deformity as the growth continues. As the vertebrae grow, the graft does not grow in length and an increased torsion results. Besides, the curvature in the areas above and below the fusion increases

inasmuch as the longest possible graft taken from the tibia is too short to immobilize a segment of the spine of sufficient length. He drew this conclusion from eleven cases operated on by the Albee method; three additional cases were failures due to faulty technique.

Fèvre & Bureau (49) advanced a similar opinion, maintaining that the recidives always occur below the graft. They describe Ombredanne's modification of the Albee fusion, which consists of splitting the spinous processes, severing both halves at their bases, maintaining the periosteum, which is elevated from the laminae. The graft does not lie in the midline for its whole length but deviates to one side as the curve may be. The advantage of this procedure according to the authors is that the graft is deeply imbedded in an osteoperiosteal channel.

Fèvre (48) described another modification, devised by Georges Huc. The tops of the spinous processes are divided obliquely. The periosteum is not severed on one side, but elevated from the adjacent laminae. The spinous processes are then sectioned at their bases and a tibial graft then placed in a bed thus formed.

Gruca (69) described a technique similar to Ombredanne's only he split both the spinous processes and a part of the laminae and placed two tibial grafts in an entirely osseous bed.

Frejka (55) used several thin tibial grafts instead of one solid and added cancellous bone from the tibia to the fusion area.

Leclerc (118) in one case fused the cervical spine in a seven and one half year old child by placing two fibular grafts on the cervical laminae in order to form a splint on each side of the spinous processes.

Mathieu (131) in a case of a paralytic scoliosis, a forty-six year old female, fused three short segments of the spine by osseous grafts. The first segment was D_{12}–L_1, the second done four weeks later was D_3–D_7 and the third done another ten weeks later was L_5–S_1. The immediate result was described as good.

Matchett (130) in 1939 reported a procedure conceived and worked out by Moore consisting of fusing short segments of the spine at three points after correction in a Minerva jacket cut in two halves, the halves being distracted by four turnbuckles. The middle curve is fused first, then the lower and lastly the upper.

Moffat (135) in 1928 described a technique used and devised by him: "The technique consists of reflecting a flap composed of periosteum and interspinous ligaments as in the Hibbs operation from the spinous processes and laminae on the concave side. The spinous process at each pole of the incision is cleft and the intervening spinous processes broken down. A straight three layer graft, of sufficient length to reach from one cleft spinous process to another is removed from the tibia and inserted as by

the Albee technique. The periosteal flap is then sutured around this graft. In this way the graft extends from the beginning to the end of the curve as does the string in a bow".

He maintains that his technique has the following advantages:

1) Simplicity of technique.
2) Rapidity and profusion of bone production.
3) Efficient splinting action.

Young (184) denuded the spinous processes and laminae of periosteum. He then placed osteoperiosteal grafts of about two millimetres thickness taken from the tibia on both sides of the spinous processes. "I have performed this vertebral arthrodesis on a few scoliosis patients. The proliferation of bone that followed the operation and the stability of the fused section of the spinal column were very gratifying".

Hibbs first described his spine fusion operation in 1911 (85) and did his first spine fusion for scoliosis in June 1914. In 1917 (86) he published eight cases so treated, in 1924 fifty-nine (87) and in 1931 with Risser & Ferguson (88) a report on 360 cases operated on from June 1914 to June 1927. Of these 360 cases 285 had a follow-up study of two to fifteen years after operation. No case, fused at seventeen years or older, had an increase in curvature. Thirty-three patients operated upon while very young were not out of the adolescent period when the study was done and the results were not considered as final. After subtracting these cases the results were as follows:

1.5 per cent maintained more than 15 degrees of correction
21 per cent maintained from 5–15 degrees of correction
47 per cent showed no increase of curvature
30.5 per cent showed an increase of the deformity.

Pseudarthrosis was suspected in fifteen cases and verified by operation in seven. The failure of fusion in eleven cases was at the crest of the curve and in four cases at the fourth and fifth lumbar. Ten of the fifteen had extensive infantile paralysis. The mortality rate was 1.6 per cent.

Smith & al (162) in 1938 published a review of 265 cases treated by Hibbs' fusion after previous correction by the wedging jacket. The results are shown in Table 2 taken from the publication.

Pseudarthrosis occurred in the fusion area in sixty-one cases or 23 per cent. Forty-seven patients were operated on again and the defect repaired.

There were 213 females and eighty-eight males. The mortality rate was 0.66 per cent (two cases). The patients were observed from one to ten years after operation, with an average follow-up period of 4.4 years.

Whitman, A. (174, 175) in 1922 reported 15 cases operated upon by

Hibbs' method; the first case was in 1920. Almost all patients were fully grown at the time of operation. He did not see increase of curve after the operation.

Thomas (167) advocated the addition to the Hibbs fusion of one or two osteoperiosteal grafts taken from the tibia. The grafts are supposed to have high osteogenetic power but no splinting action. Lewin (121) and Allison (3) described essentially the same principle.

TABLE 2

	Mild 25 degrees or less	Moderate 25 to 50 degrees	Severe over 50 degrees
No. of cases	14	125	118
Correction by jacket ...	95 per cent	69 per cent	50 per cent
Corr. maintained	80 per cent	49 per cent	30 per cent
Body balance before op.	Good	Fair	Poor
Body balance after op.	Excellent	Excellent	Good

Kleinberg (102, 103, 105, 106) used beef bone graft to strengthen the Hibbs fusion. The beef bone should act as a framework for new bone growth and as a splint. In some cases pieces of ribs taken from the backwards projection of the deformed ribs were used as splints. In 1929 he had operated on 90 cases, 54 being followed for one to five years. The results were:

Excellent	*Good*	*Failure*
42 (78 per cent)	7 (13 per cent)	5 (9 per cent)

There was one death.

Tavernier (166) used horse bone graft in a few cases but gave it up again because the graft did not take. If the graft was placed superficially it was extruded, placed deep, it was resorbed.

TABLE 3

Type of operation	No. of cases	Fused	Not fused
Hibbs	46	24	22
Hibbs + tibial graft	23	20	3
Hibbs + rib graft	19	18	1
Hibbs + beef bone graft	12	4	8
	100	66	34

Brogden (18) in 1936 published a review of 100 cases of scoliosis treated by spine fusion. These 100 cases were chosen out of 500 cases because they could be followed up and there were available pre- and post-operative X-rays. The length of the follow-up period is not stated. His results may be seen from Table 3.

The mortality rate was 1 per cent and the cause of death was heat stroke. It is not mentioned where this case is classified in the table.

MATERIAL

From January first 1936 to December thirty-first 1942, 208 new cases of scoliosis were operated on in the New York Orthopedic Hospital. Of this number thirty were paralytic, six congenital and two thoracogenic. The vast majority, however, or 170 were of unknown etiology or idiopathic.

The female patients numbered 164 (79.2 per cent) and the male patients were forty-four (20.8 per cent), the female-male ratio being 4 : 1.

In the scoliotic spine there is never one curve alone; there are always at least two and usually three, one of them being most pronounced and the others of less severity. The most deforming one will here be called the primary curve, the others compensatory. Apart from that, the principles described by Ferguson (47) were applied to determine the primary curve.

In the few cases where formation of the curves could be followed all the way back to the beginning of the deformity, the changes always occurred first in that segment of the spine which subsequently became most deformed, that is, the primary curve, the others apparently developing gradually to compensate the deformity, the ultimate end being that of keeping the center of gravity of the body over the area of support and the eyes level. No attempt, however, will be made to prove or investigate whether the actual deforming forces are at work only in the primary curve or all over the spine.

A curve in the area D_1 to D_{12} is called a dorsal curve. If it extends farther downwards it is called dorso-lumbar.

Occasionally two curves may be so similar that it is hard to tell which is the most deforming and both of them show the features of a primary curve; these are termed double-primary. Of these curves one is always dorsal, the other dorso-lumbar.

There is, of course, no sharp borderline. A dorsal curve extending to D_{12} and a dorso-lumbar one extending only to L_1 behave very similarly in every respect. However, as there is some difference in the behavior of the curves according to the localization, it was thought wise to examine them in two groups and this division was considered to be the most nearly correct both anatomically and functionally.

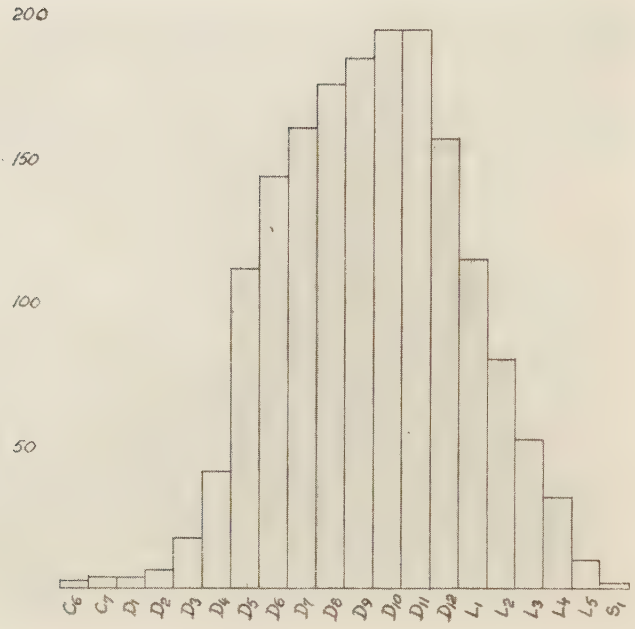


Fig. 6.
Incidence of involvement of vertebrae in 218 primary curves.

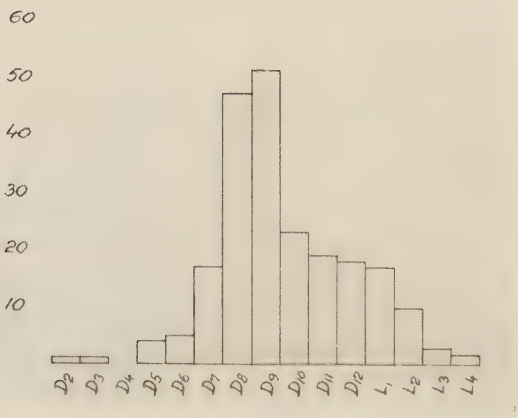


Fig. 7.
Localization of the apex of 218 curves.

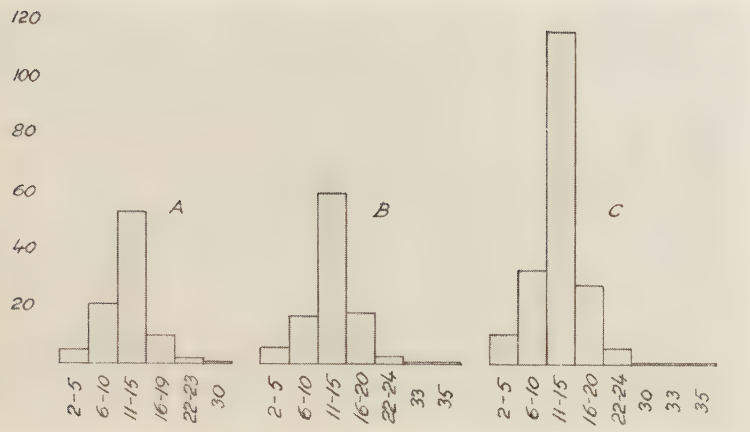


Fig. 8.

Age when first seen in clinic. A. dorsal curves, ninety-two cases, forty-six patients (50 per cent) were twelve to fifteen years old. B. dorso-lumbar curves 106 cases, fifty-two patients (52.8 per cent) were twelve to fifteen years old. C. all curves, 208 cases, 104 patients (50 per cent) were twelve to fifteen years old.

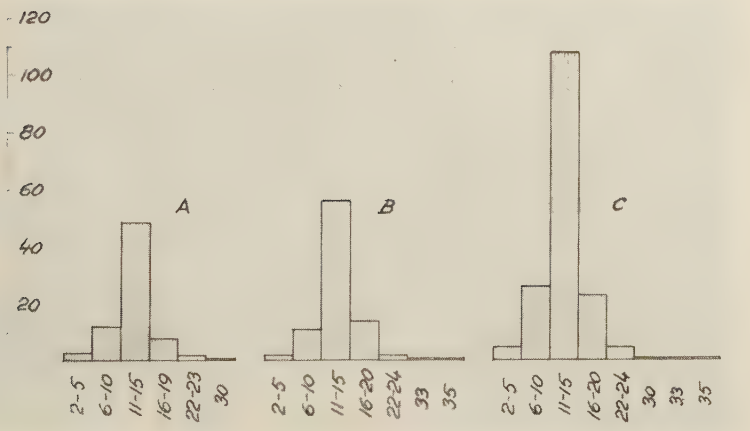


Fig. 9.

Age when first seen in clinic, idiopathic curves. A. dorsal curves, forty-two patients (56.8 per cent) were twelve to fifteen years old. B. dorso-lumbar curves, fifty-one patients (58.6 per cent) were twelve to fifteen years old. C. all curves, ninety-seven (57.1 per cent) were twelve to fifteen years old.

In the dorsal curves, the rib deformity is always of great importance and is usually the most deforming feature, besides being the factor that puts greatest stress on the circulatory system and the respiratory function.

In the dorso-lumbar cases, especially those extending far downwards, a prominent hip and a shift of the trunk to one side may be the most pronounced deformity.

The lateral mobility of the spine increases from above downwards. The higher curves are therefore more rigid and less correctible than the lower ones. An indication of the mobility can be seen in the amount of correction that takes place when the patient changes position from standing to lying.

The localization of the primary curve is shown in Table 4. There are ninety-two dorsal curves (44.23 per cent), 106 dorso-lumbar (50.96 per cent) and ten double primary (4.81 per cent).

The primary curve is more often convex to the right. Right dorsal plus right dorso-lumbar total 154 (74 per cent). If the double primaries are added, one of which is always convex to the right, the number of right curves becomes 164 (78.8 per cent), that is, nearly four out of every five primary curves are convex to the right side. Of the primary curves, the pure dorsal amount to only a little over 40 per cent. The main deformity actually is localized in the dorsal segment of the spine much more often. Of the dorso-lumbar curves, seventy-three begin at D_7 or higher and thirty-seven of them extend only to L_1.

The 208 patients presented 218 primary curves. The average number of vertebrae involved in a primary curve was 7.75. The incidence of involvement of each vertebra is shown in Fig. 6.

A thirteenth dorsal vertebra present in five primary curves is not recorded on the graph. Also a twelfth dorsal vertebra was absent in fifteen cases where it would have been involved in a primary curve had it been present.

The apex of the curve is most frequently localized in the lower part of the dorsal area, D_8 and D_9 accounting for 98 (44.95 per cent) or nearly one-half of all the curves (Fig. 7).

The age of the patients when they came to the clinic because of a lateral curvature of the spine, or, in a few cases when a scoliosis was discovered in the clinic, the patient having come in for another ailment, ranged from two to thirty-five years. 90 per cent, however, were from six to twenty years of age and 104 or 50 per cent were twelve to fifteen years old (Fig. 8).

If the idiopathic curves are viewed separately, they show about the same pattern only a slightly tighter grouping around the eleven to fifteen year class (Fig. 9).

TABLE 4

	M	F	M + F		Per cent	
Right dorsal	15	64	79	92	37.98	44.23
Left dorsal	7	6	13		6.25	
R. dorso-lumbar	16	59	75	106	36.06	50.96
L. dorso-lumbar	5	26	31		14.90	
R. dorsal-L. lumbar	1	7	8	10	3.85	4.81
L. dorsal-R. lumbar	0	2	2		0.96	
	44	164	208		100.00	

Another question of more interest is, when did the deformity begin?

To determine the exact time of onset of a lateral curvature in a given patient, a series of Roentgenograms would have to be available, taken every three or at least every six months, starting before the occurrence of the deformity. It is obvious that such series cannot be had for any number of scoliotic patients. It is necessary, therefore, to rely upon the observation of the patients themselves and their relatives. Sometimes a physical instructor notices a hump in the back and quite often a dressmaker points out a prominent hip or a high shoulder while fitting a dress. The deformity develops so gradually that it often escapes the notice of the patient or his parents in the beginning and sometimes until it has reached quite a severe degree. Then all of a sudden it is discovered and the patient is brought to the doctor for "a hump in the back that was not there a month ago". The curve may be quite rigid, the X-ray films show structural changes in the vertebrae that have needed years to develop, but the patient and his family are sincere in their belief, "a month ago it was not there".

Of course some parents have a keen sense of observation and notice the deformity very early.

Figures computed on the basis of personal histories cannot be accurate for this reason. The difference between these and the correct figures, however, should be mostly if not entirely to one side, presenting the duration of the deformity shorter than it actually is.

Fig. 10 shows the age (in five year groups) when the curvature was first noticed by the patient or his relatives in all the patients except six where no information was available on that point.

163 patients (80.7 per cent) were in the ten year group from six to fifteen and in the four year period from ten to thirteen years the deformity was first noticed in 105 cases (52 per cent).

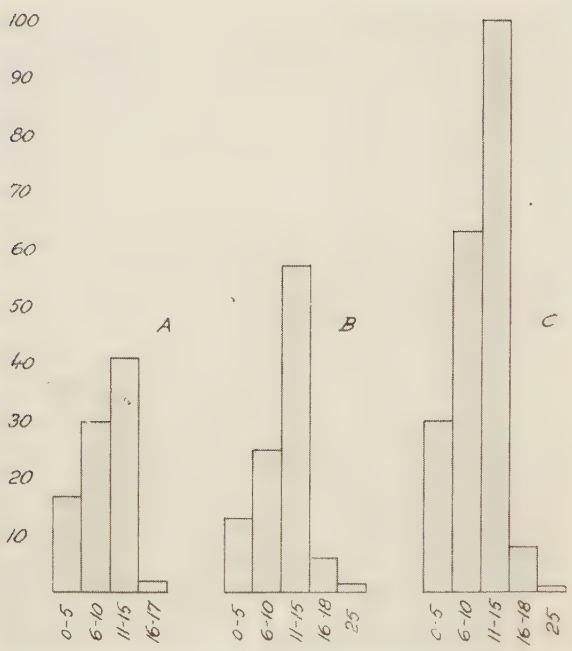


Fig. 10.

Age when first noticed by patient or relatives. A. dorsal curves, forty-two patients (46.7 per cent) were ten to thirteen years old. B. dorso-lumbar curves, fifty-seven (56 per cent) were ten to thirteen years old. C. all curves, 105 (52 per cent) were ten to thirteen years old.

Fig. 11 shows the corresponding figures for the idiopathic curves, showing a tighter grouping in the late childhood.

The idiopathic cases in question were 164 with 148 (90.2 per cent) six to fifteen years old and ninety-three (56.7 per cent) ten to thirteen years of age.

The age at the first operation is seen in Fig. 12 for the idiopathic curves. 104 (61.2 per cent) were operated on before the end of the fourteenth year. Fig. 13 shows the corresponding figures for all the cases.

When the patients first came to the scoliosis clinic, they were given exercises in the physical therapy department. If operation was decided upon immediately, the exercises were intended to strengthen the musculature and to limber the spine. In the cases where the deformity was not so severe as to warrant operation at once or when the patients were reluctant to accept surgical interference, perhaps the most important indication for the physical therapy was to keep the patients in touch with the clinic. An improvement of the deformity was not expected by this treatment.

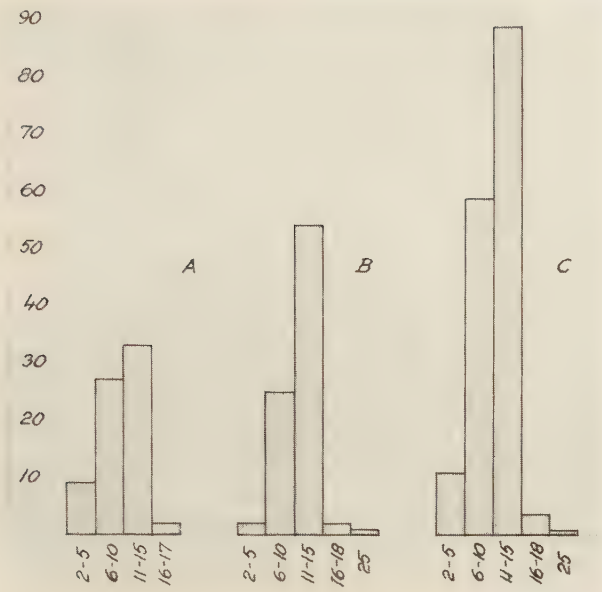


Fig. 11.

Age when deformity was first noticed by patients or relatives. Idiopathic curves. A. dorsal curves, thirty-seven patients (52.1 per cent) were ten to thirteen years old. B. dorso-lumbar curves, fifty-two (61.9 per cent) were ten to thirteen years old. C. all curves, ninety-three (56.7 per cent) were ten to thirteen years old.

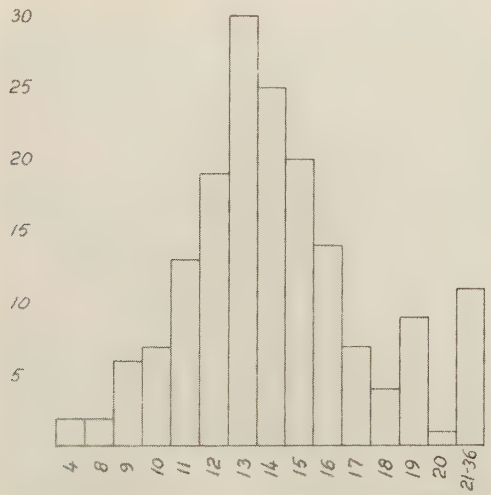


Fig. 12.

Age at operation. Idiopathic curves, 170 cases. 104 patients (61.2 per cent) were fourteen years or less at the time of operation. In cases of double primary curves or when the fusion was subsequently extended, the age referred to here is when the patient was first operated on.

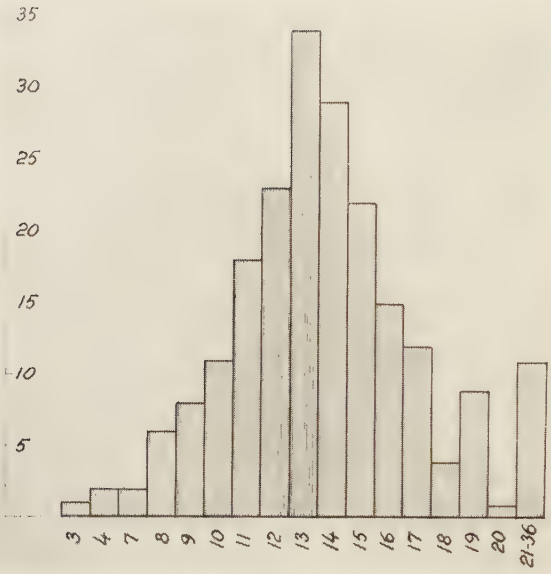


Fig. 13.

Age at operation. All curves, 208 cases, 134 patients (64.4 per cent) were fourteen years old or less at the time of operation.

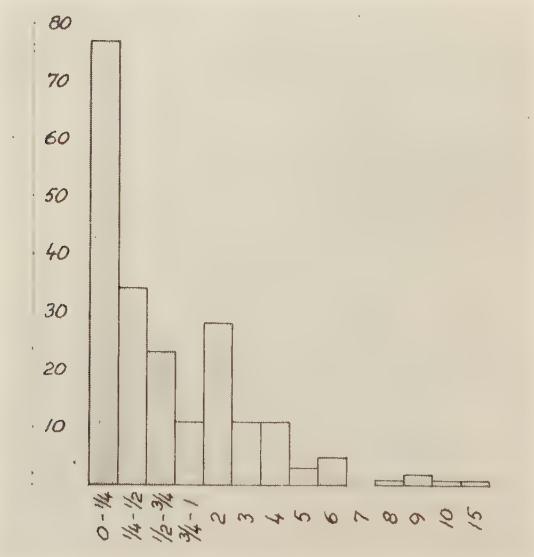


Fig. 14.

Years followed in clinic before admission to hospital for surgical treatment.

In the first six months after the patients' initial visit to the clinic 111 (53.4 per cent) were admitted to the hospital for correction and fusion and in the first year 145 (69.7 per cent) were admitted for surgery (Fig. 14).

In thirteen cases there was an interval of five or more years between the original attendance at the clinic and the surgical treatment.

Four of these patients had not been seen in the clinic for a number of years, in six cases the curvature was stationary for a long period and in three cases operation was refused in the beginning. All of these last three consented to surgery later because of pain in the back.

TREATMENT

The treatment consisted of correction of the primary curve, fusion of the corrected segment of the spine by the Hibbs method and immobilization for nine months following operation.

To record the curvature of the spine, Roentgenograms are essential. Photographs may be of value to show the gross cosmetic lesion, prominence of one hip, elevation of one shoulder, list of the trunk and posterior rib deformity, but they do not show the actual curvature of the spine. In muscular and adipose patients they may be very misleading. On the Roentgenogram, however, the vertebral column is visible and can be measured fairly accurately.

The method of measuring employed was that described by Ferguson (47): "At each end of a curve that vertebra, which is nearest to neutral, that is, unrotated, is selected as the end vertebra, and at the crest of the curve, that vertebra which is most rotated is selected as the apex. In each of these three vertebrae the center of the shadow is marked. Lines are drawn from the apex to each end. The angle of the curve is the difference between the angle formed by these two lines and 180 degrees".

Ferguson (47) estimates the limit of error by this method not to exceed 3 degrees and Hibbs et al. (88) state that "the limit of error by this method is from 3 to 5 degrees".

To establish the accuracy of the measurements contained herein Roentgenograms of twenty curves were chosen at random and each of them was measured ten times. The precision index, σ, arrived at equalled 1.1 or for practical purposes 1 degree.

σ is determined by the following equation

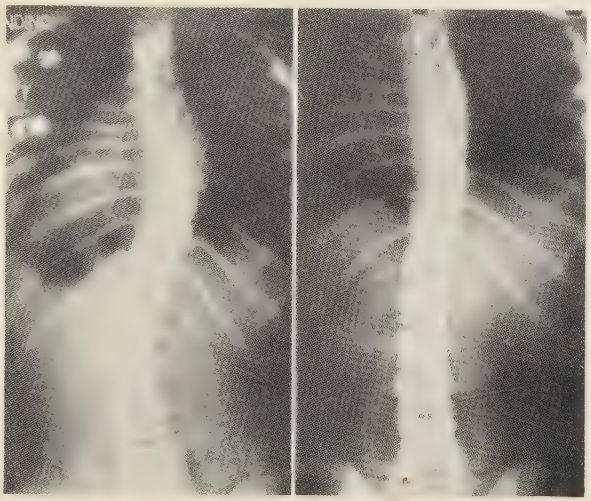
$$\sigma^2 = \frac{(t_1 - m)^2 + \cdots + (t_n - m)^2}{n - 1}$$

where m is the mean of the measurements, $t_1 \ldots t_n$ the individual measurements and n their number.

In a series of individual measurements the variations lie between

$a \pm 3\sigma$ (a, being the actual curvature) in 99.7 per cent of the cases. Therefore, in this material, any given curve may be regarded to be accurately measured within the limits of $\pm$ 3 degrees.

The correction of a given curvature is the difference between two measurements. If this difference is more than $\sqrt{2} \cdot 3\sigma$ there is an actual difference between the two curves and, therefore, the accuracy of the



A *Fig. 15.* B

Correction of a curvature by changing position from standing A., to lying B.

method may be said to be $\sqrt{2} \cdot 3\sigma$. It is safe to assume that a difference of 5 degrees is real and not due to error in measurement.

However, one other factor may influence the accuracy of a method based on the measuring of a curvature on the Roentgenogram. The position of the patient may vary slightly from one exposure to the next so that the projection on the film is not always exactly the same. This source of error has not been made a subject of investigation as it may be assumed that in a fairly large material these variations neutralize one another.

The correction was effected by a Risser turnbuckle jacket (Hibbs, Risser & Ferguson (88), Risser (143), Smith (160, 161)). The entire trunk is encased in a plaster of paris jacket which includes the chin and occiput and one thigh. Hinges are incorporated both in front and back. A wedge is cut out on the convex side of the curve and the concave side of the cast is split. A turnbuckle is inserted and the two halves of the cast wedged over, turning on the hinges. When maximal correction has been obtained the cast is reinforced by struts in the sides, the turnbuckle removed and a window cut in the back. The operation is performed through

the window which is subsequently closed and the patient remains in this cast for three months, when the original cast is removed and a new plaster jacket applied in a somewhat straighter position than the wedging jacket, but still somewhat bent, in which the patient is ambulatory for three months. Then a straight walking jacket is worn for another three months at the end of which all support is discarded.

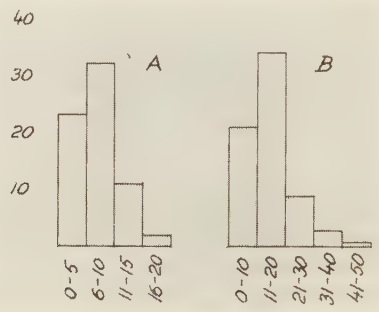


Fig. 16.

Correction on lying down in sixty-eight dorsal curves. A. in degrees, B. in per cent of the original curve. Average correction 7.3 degrees.

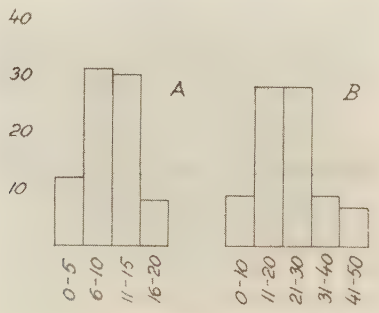


Fig. 17.

Correction on lying down in eighty-one dorso-lumbar curves. A. in degrees, B. in per cent of original curve. Average correction 10.1 degrees.

A certain amount of correction is obtained simply by having the patient change position from standing to lying (Fig. 15). This correction increases with the mobility of the spine from above downwards.

Twenty-seven cervico-dorsal curves in the area from C_6 to D_7 were measured by X-rays both in the standing and supine position. The greatest curve was 60 degrees, the smallest one 11 degrees standing. The maximal difference between lying and standing was 4 degrees, the average being 1.4 degrees.

Sixty-eight dorsal curves had both standing and lying X-ray examination a short time before therapy was instituted. The average correction on lying down was 7.3 degrees, maximum 16 degrees. The greatest curve was 105 degrees, the smallest one 21 degrees (Fig. 16).

The correction on lying down in eighty-one dorso-lumbar curves (in the region from D_3 to S_1) was 10 degrees, maximum 19 degrees, the greatest curve standing was 101 degrees, the smallest one 24 degrees (Fig. 17).

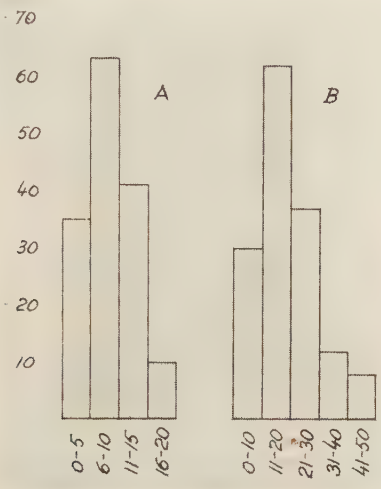


Fig. 18.

Correction on lying down in 149 dorsal and dorso-lumbar curves. A. in degrees, B. in per cent of original curve. Average correction 8.9 degrees.

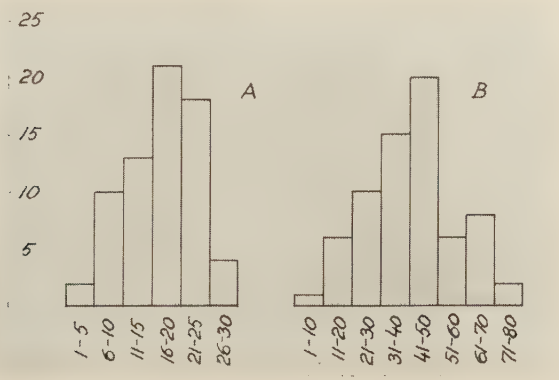


Fig. 19.

Forcible correction (that is, correction in jacket from the lying position) in sixty-eight dorsal curves. A. in degrees, B. in per cent of the original curve lying. Average correction 16.5 degrees.

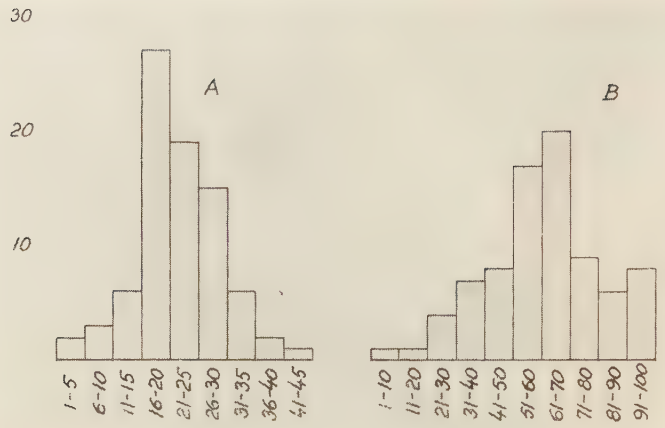


Fig. 20.

Forcible correction (correction in jacket from the lying position) in eighty-one dorso-lumbar curves. A. in degrees, B. in per cent of the original curve lying. Average correction 21.5 degrees.

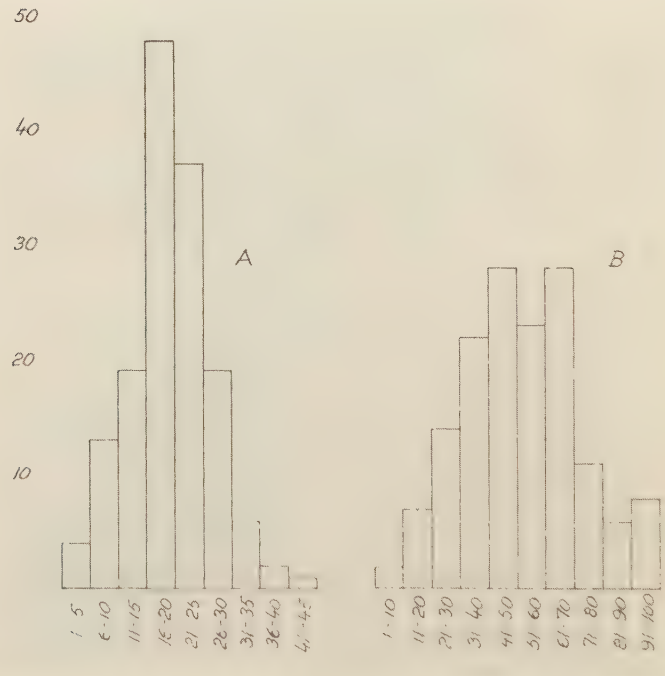


Fig. 21.

Forcible correction (correction in jacket from the lying position) in 149 dorsal and dorso-lumbar curves. A. in degrees, B. in per cent of the original curve lying. Average correction 19.25 degrees.

Fig. 18 shows the correction on lying down for 149 dorsal and dorso-lumbar curves.

The forcible correction of the wedging jacket begins at the supine position when the slack of the spine has been taken up.

Fig. 19–21 show the forcible correction obtained and again the greater mobility of the lower segments of the spine is evident. The average correction of the dorsal curves is 16.5 degrees and of the dorso-lumbar curves 21.5 degrees. The peak of the graph lies 20 per cent higher for the dorso-lumbar curves than for the dorsal. The average correction for both dorsal and dorso-lumbar curves taken together is 19.25 degrees. Of the dorsal curves fifty-two (76.5 per cent) had a correction of 11 to 25 degrees and fifty-one (75.0 per cent) had a correction of 21 to 60 per cent.

Of the dorso-lumbar curves sixty-seven (82.7 per cent) were corrected from 16 to 30 degrees and fifty-four (66.7 per cent) had a correction of 41 to 80 per cent. Another indication of the greater rigidity of the upper part of the spine is that none of the dorsal curves could be wholly corrected, whereas seven of the dorso-lumbar curves could be straightened out completely.

The position usually referred to, however, is the standing and the correction mentioned is the correction obtained from the same position, as it is of minor importance to the patient how straight his spine is when he lies supine. Fig. 22–24 show this correction. These graphs follow the same pattern as the previous ones and are, as was to be expected, very close to being the sum of the correction on lying down and the forcible correction.

Out of 91 dorsal curves sixty-two (68.1 per cent) had a correction of 16 to 30 degrees and seventy-one (78.0 per cent) were corrected from 31 to 70 per cent of the original curve.

Of 105 dorso-lumbar curves seventy (66.7 per cent) had a 26 to 40 degrees correction and 76 cases (72.4 per cent) were corrected 41 to 80 per cent.

The graph showing the relative correction of both dorsal and dorso-lumbar curves taken together shows two peaks, the first one is built up by the rather rigid high curves, the second indicates the more mobile lower ones. These graphs are based on 196 dorsal and dorso-lumbar curves. The double primary curves were not included and in two cases, one dorsal and one dorso-lumbar, no correction was attempted.

In the dorsal curves a correction of more than 40 per cent of the original curve is to be expected in 73.6 per cent of the cases and in the lumbar curves 76.2 per cent may be expected to have a greater correction than 50 per cent.

The severe curves of long standing with marked structural changes in

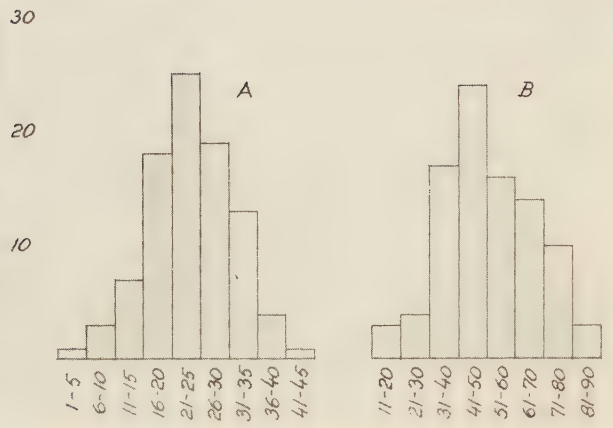


Fig. 22.
Total correction in ninety-one dorsal curves. A. in degrees, B. in per cent of the original curve. Average correction 22.2 degrees.

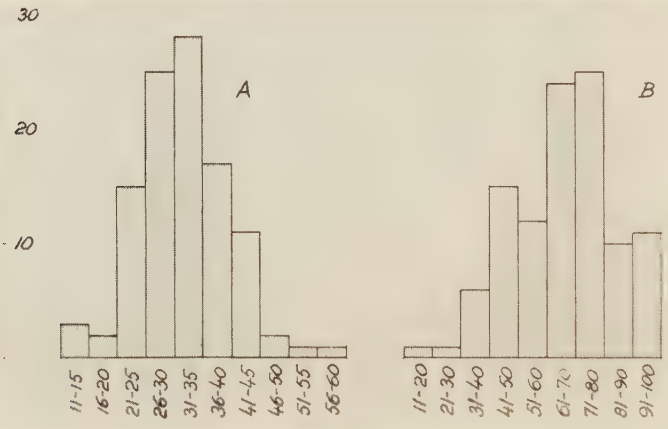


Fig. 23.
Total correction in 105 dorso-lumbar curves. A. in degrees, B. in per cent of original curve. Average correction 32.8 degrees.

the vertebrae have a lesser chance of correction than the milder ones of a short duration.

The selection of the fusion area was guided by the following principles (Ferguson (47), Butte (22)):

1) The minimum fusion area must include the entire primary curve.
2) It is preferable to extend the fusion into the compensatory curves to such a degree that the end surfaces of the last vertebrae fused

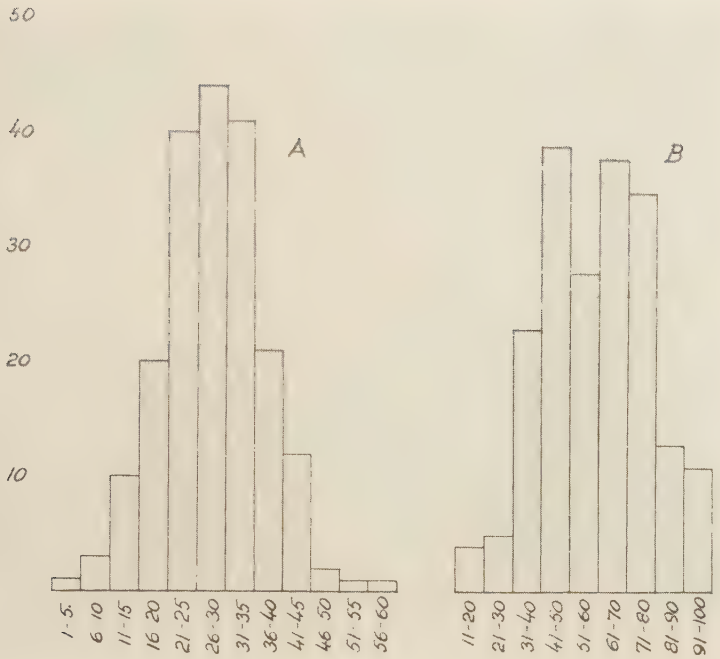


Fig. 24.
Total correction in 196 dorsal and dorso-lumbar curves. A. in degrees, B. in per cent of original curve. Average correction 27.8 degrees.

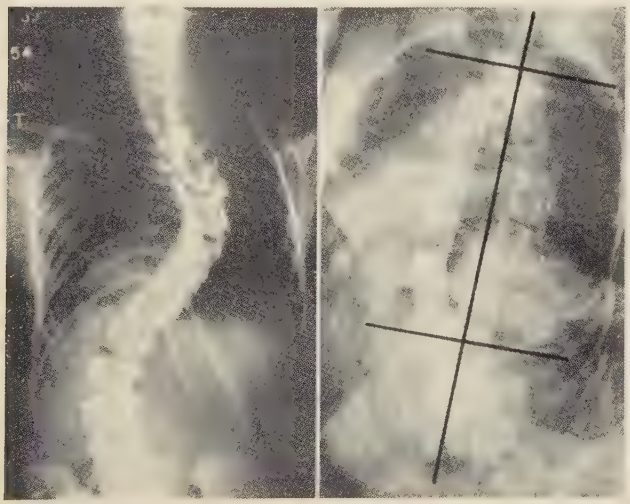


Fig. 25.
Selection of fusion area.

are parallel and at right angles to a line joining their centers (Fig. 25).

3) The patient must be correctly postured. A pelvic tilt because of a short leg must be taken into account.
4) The fusion area is selected after maximum correction has been obtained in the wedging jacket.

To ensure that all the vertebrae intended are fused, and only these, a landmark is necessary. Over the spinous process of one of the vertebrae in the area to be fused a line was drawn with gentian-violet stain, a metal wire placed over it and a Roentgenogram made. At the operation this spinous process was easily identified.

The Hibbs technique of spine fusion was used in every case.

The skin incision was either curved, following the tips of the spinous processes or in some cases straight, placed slightly to the concave side of the curve. The straight incision is to be preferred when possible. A curved scar creates an appearance of asymmetry even on a straight back, whereas a straight scar tends to lessen the appearance of the deformity.

A careful subperiosteal stripping of the spinous processes and laminae as far as the articular facets followed.

The posterior half of the ligamentum flavum and the capsules of the lateral articulations were removed by a curette. The spinous processes were split longitudinally and cut at their bases. The cartilage was removed from the articulations by a curved chisel and a curette and a piece of bone removed from a lamina wedged into the gap. The posterior surfaces of the laminae were cut into chips which were placed across the articulations and the interlaminar spaces (Fig. 26). If additional bone was available it was distributed over the fusion area. Wound closure in layers.

In most of the cases the fusion was done in two stages, usually three to four weeks apart. If only four or five vertebrae are fused at one time the danger of shock is practically eliminated and if blood transfusion is given during the operation the shock can be said to be non-existent. All the patients stood the operation well. There were no postoperative deaths.

In twelve cases the fusion was done in one stage. Twenty-two patients had three stage operation or the fusion area was subsequently extended. In five cases the fusion was done in four stages. That makes a total of 436 operations or 2.09 operations per patient. The average number of vertebrae fused was 9.3 per patient.

Thirty-three pseudarthroses were repaired in thirty-one patients. Additional nine patients were suspected of failure of fusion and explored, so the total of the operations done is 478 or 2.3 operations per patient.

In twenty-six cases additional bone was used to increase the new bone

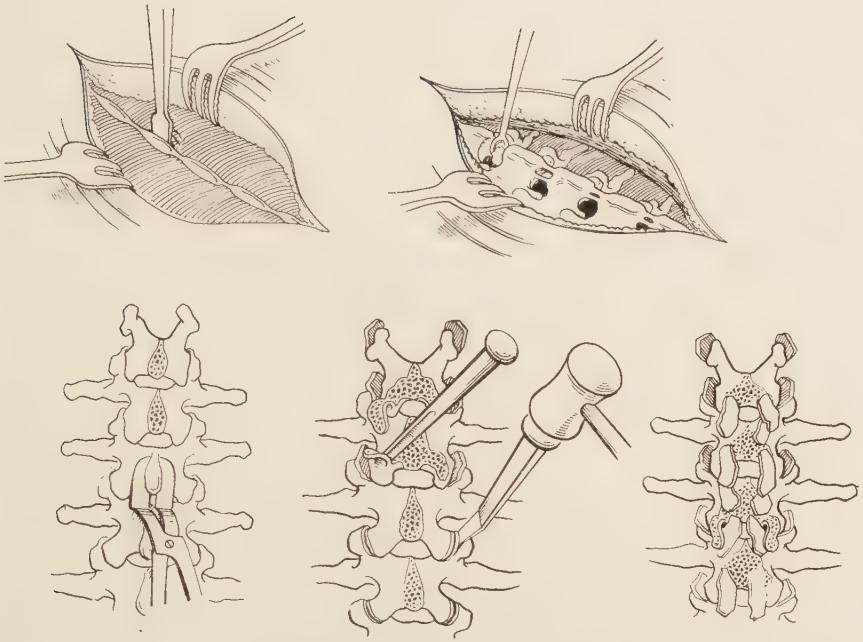


Fig. 26.
Technique of the Hibbs spine fusion.

formation and strengthen the fusion. In twenty-one cases the bone was taken from the upper end of the tibia in the form of bone chips, mostly cancellous. In three cases chips were taken from the iliac crest and twice homogenous bone was used.

In one case a pseudarthrosis occurred through an area of additional bone. In this case bank bone was employed as described by Bush (21). The other case, where homogenous bone was used, was operated on in October 1939. Bone strips obtained from ribs resected from another patient were used for reinforcement. The bone had been kept in an icebox in a sterile tube for three days and was autoclaved for thirty minutes before using. The postoperative course was uneventful. In October 1942 the patient apparently had lost all correction. He had no pain or tenderness and was leading a normal life. He was not seen later in the clinic and could not be located for a follow-up study.

LOSS OF CORRECTION

The diagnosis of a pseudarthrosis in a fusion area is by no means easy, as can be judged by the fact that in nine cases which were operated on with a suspicion of pseudarthrosis no pseudarthrosis was found. Three of these, however, presented weak areas composed of immature bone which may be held equivalent to a pseudarthrosis. That still leaves six out of forty-two operations, or one seventh of the cases, where a suspected failure of fusion was not found.

The diagnosis is based on both roentgenological and clinical findings. In a few cases an unmistakable defect may be seen in the fusion plate (Fig. 27), but usually only a weak area can be spotted and it may prove impossible to determine if it represents a break in the fusion or merely a more translucent zone composed of thinner or immature bone. Laminograms are often of great help but may fail to be conclusive. The clinical findings are pain increasing on motion and exertion, tenderness of the area in question and loss of correction, especially if most or all of the correction loss appears at one joint. Absolute certainty, however, can only be had when a pseudarthrosis is found at operation. Therefore, only the pseudarthroses verified by operation are listed.

There were three additional cases in which a pseudarthrosis was suspected. In one case the patient lost 20 degrees of correction but remained well balanced and had no symptoms from the suspected fusion failure. In the second case operation was refused and in the third case the patient had not returned to the clinic after the pseudarthrosis was suspected.

Forty patients suspected of having pseudarthrosis were operated on for the second time. Nine of these cases were found to have no break in the fusion, thirty-one (14.9 per cent) had a pseudarthrosis which was repaired and two of these were operated on for a third time. As the 208 patients had 436 operations done, the incidence of pseudarthrosis is 7.6 per cent of the operations.

Of the thirty-three pseudarthroses, eleven were through the junction area between the first and second stage fusion and seven additional through the next higher or lower joint. In two cases it could not be determined if

the pseudarthrosis was through the junction area or the next joint. Thus twenty (60.6 per cent) or nearly two thirds of the pseudarthroses encountered were either in the immediate vicinity or right through the junction of the two fusion areas. This seems to be the weakest spot in the fusion and should be reinforced by a liberal amount of highly osteogenetic bone whenever possible.

Fig. 27.
A defect in a fusion plate.

In four cases cartilage was found to be present in the lateral articulations indicating that the fusion technique had not been carried out meticulously enough. Despite the preference of many surgeons not to disturb the lateral articulations, it is obvious that arthrodesis at these points is bound to strengthen the fusion greatly. In fact, solid natural fusion is sometimes seen only through ankylosis of these articulations. Haas (76) on basis of experiments on dogs, recommends the destruction of the intervertebral articulations in order to obtain the most rapid and efficient fixation.

The pseudarthroses detected were distributed as follows according to the localization of the curve:

Of ninety-two dorsal curves, there were three pseudarthroses (3.3 per cent).
Of 106 dorso-lumbar curves, there were twenty-four pseudarthroses 22.6 per cent).
Of twenty double primary curves, there were six pseudarthroses (30.0 per cent).

Of the six pseudarthroses in the double primary curves, one was located at D_4–D_5 and the other five were all in the lower curves.

According to the etiology of the curves, the distribution was thus:

Of 170 idiopathic cases, there were twenty-two pseudarthroses (12.9 per cent).
Of thirty paralytic cases, there were ten pseudarthroses (33.3 per cent).
Of six congenital cases, there was one pseudarthrosis (16.7 per cent).

Most of the pseudarthroses appeared in the lowest part of the dorsal spine and in the lumbar region. This holds true also for those cases which had no connection with the junction of two fusion areas. Only two were located higher than the level of D_9.

An increasing mobility of the spine seems to predispose to a failure of healing. This is also borne out by the fact that in one third of the paralytic cases, failure of fusion occurred in the first instance.

The mobility of the paralytic spine is greater than in the idiopathic cases, the idiopathic scolioses are often quite rigid. The mobility of the paralytic spine presents itself most clearly in the lumbar area, the rib cage offering some splinting effect to the dorsal area.

Of the paralytic cases, twelve curves extended only to D_{12} and one of these showed a pseudarthrosis. Seventeen paralytic curves were dorsolumbar; in eight of them failure of fusion appeared. The tenth paralytic case which had a repair operation, sustained a fracture of the fusion plate through the space between L_1 and L_2.

In three of the explored cases, where no pseudarthrosis was found, areas of immature, soft bone were encountered. This would indicate cases of delayed healing and call for prolonged rigid immobilization. As it is impossible to ascertain beforehand which spines will be slow in healing, it is desirable to add bone, preferably of high osteogenetic value, to every spine fusion.

Twenty-nine of the pseudarthroses were discovered within fourteen months of the original operation, three of them two years later and one after an interval of four years.

The following table shows when failure of fusion was discovered:

TABLE 5

3 months	6 months	9 months	10–14 months	2 years	4 years
6	7	2	14	3	1

At every plaster change, Roentgenograms were made and thirteen of the pseudarthroses were discovered on these occasions. Two more were found immediately after the removal of the last plaster jacket. Fourteen additional cases were discovered in the first five months that the patients were ambulatory without any support and only four cases were detected later. Whether they have escaped detection at an earlier stage or if they represent a fracture of the fusion plate cannot be determined. One patient had definite evidence of such a fracture through the fusion plate (No. 206246).

Sometimes all or most of the correction is lost at one point, where the pseudarthrosis is located, but this is not an invariable rule. Sometimes a part or the greater amount of the loss of correction is distributed over the entire fusion area, indicating that the deforming forces exert their power on the growing and still immature bone.

In fifteen of the pseudarthroses a recorrection was effected amounting to an average of 11.5 degrees before the repair operation; the maximum correction was 30 degrees.

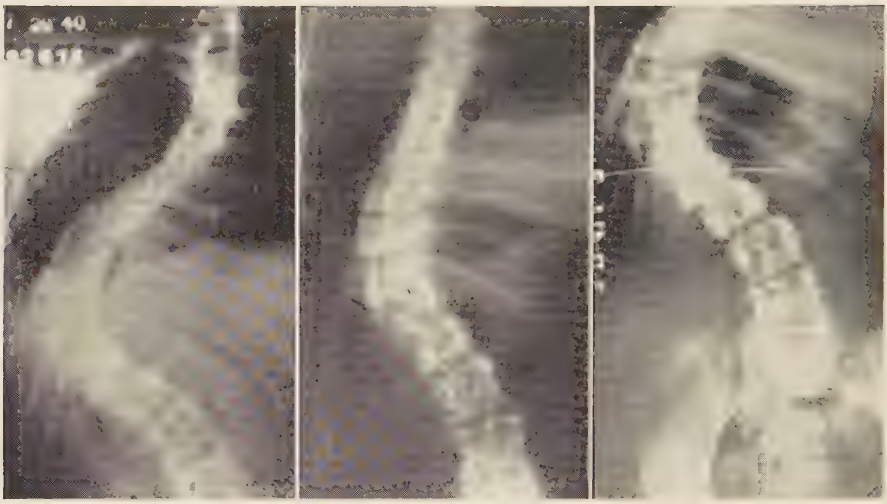
In one case there was no loss of correction despite a pseudarthrosis. Here the right lateral articulation appeared to be solid although slight motion could be elicited.

On going through the Roentgenograms it becomes evident that most recorrection was obtained in the cases which had sustained the greater part of the correction loss at one point, that is at the site of the pseudarthrosis. On the other hand, four of the explored spines where no pseudarthrosis was found, were recorrected from 9 to 15 degrees before the exploration was undertaken. In three of these cases, an area of soft immature bone was found. Usually, however, the fusion plate was found to be a bone of normal texture and, in a few cases, even especially hard.

Smith (159), in autopsy specimens which had been subjected to Hibbs' spine fusion, found a solid plaque of bone on the posterior aspect of the spine. "In the earliest specimens the bone is pitted and perforated by numerous minute foraminae and the cortex is thin but with increase in the period elapsed after operation, the surface of the bone becomes smoother and harder".

Cohen (31) reports one autopsy case on whom the second part of a two stage Hibbs fusion had been completed seven and one half months prior to death. The posterior elements of the spine were fused into a continuous sheet of bone in which even strong manual force failed to produce any motion. The patient in question was a ten and one half year old female operated on for idiopathic scoliosis. The loss of correction since the operation was six degrees.

Until all of the fusion plate has attained normal strength it is pliable.



B C

D E

Fig. 28.

Some loss of correction is therefore the rule in all fused scoliotic spines although in some instances it may be very slight and in a few cases there is no loss of correction at all.

A few cases may illustrate the loss of correction where a failure of fusion was found:

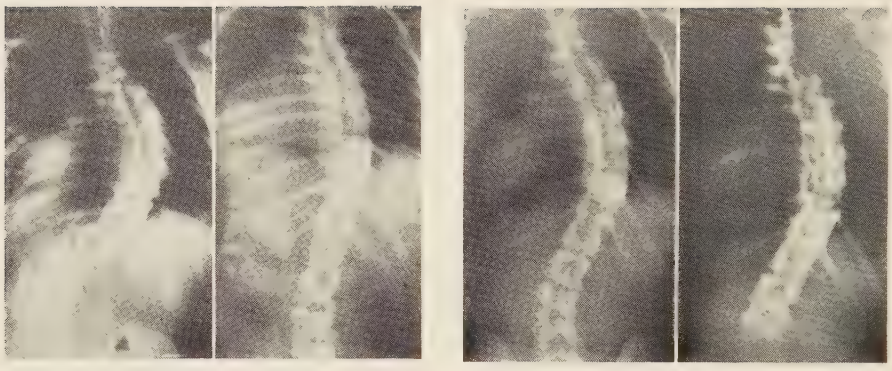
No. 159596 female born 2.X.25
Poliomyelitis in 1931
Spine fusion D_6-D_{11} 17.IV.40
D_{11}-L_2 8. V.40

A B C

D E

Fig. 29.

The original curve extended from D_8 to L_2 with apex at D_{12} and was 76 degrees standing (Fig. 28 A). It was corrected to 44 degrees prior to fusion. At the first plaster change it was 48 degrees (Fig. 28 B). Eight months later the curve had increased to 63 degrees (Fig. 28 C), most of



A B C D

Fig. 30.

the loss of correction appearing at D_{11} to D_{13}. There was pain in that area. The patient was readmitted, the curve corrected again to 44 degrees.

19.V.41. Repair of a pseudarthrosis between D_{12} and D_{13}. At the apex of the curvature D_{12}–D_{13} there was a pseudarthrosis extending completely across the fusion area. The remainder of the fusion area was found to be entirely solid.

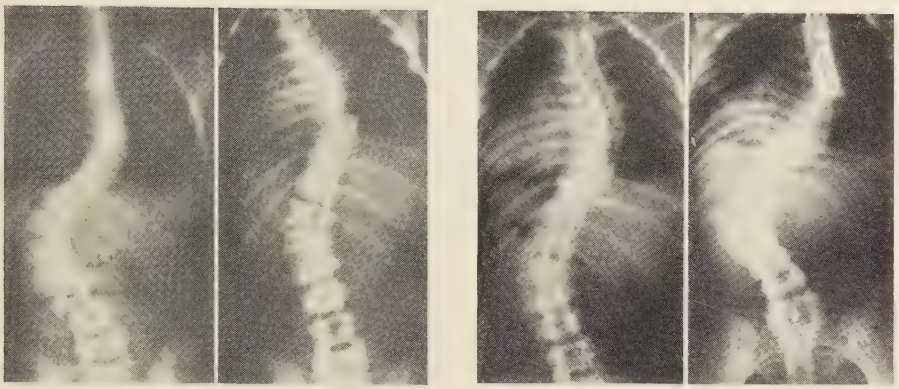
Three months later the curve measured 50 degrees (Fig. 28 D) and lost another 5 degrees in the next eight months. There was no further loss of correction and on 2.II.46 it remained stationary at 55 degrees (Fig. 28 E).

No. 225987 female born 15.VII.27
Idiopathic scoliosis
Spine fusion D_9-L_1 17. XI.39
D_5-D_9 8.XII.39
D_2-D_5 3. I.40

Original curve D_3–D_8–L_1, 55 degrees standing (Fig. 29 A) corrected to 14 degrees before fusion. Gradual loss of correction in one year to 48 degrees (Fig. 29 B-D). There was tenderness at the apex of the fusion. The patient was readmitted 12.II.41 and the curve corrected to 30 degrees.

11.IV.41. Repair of pseudarthrosis. A one millimetre defect in the firm bony mass was seen at D_5 and definite motion with respiration was demonstrated. The patient lost 10 degrees of correction in six months and remained stationary at 40 degrees (Fig. 29 E).

No. 230436 female born 26.III.21
Idiopathic scoliosis
Spine fusion D_9-L_1 22.IV.40
D_4-D_9 13. V.40



A B C D

Fig. 31.

Original curve D_5–D_9–L_1, 55 degrees standing (Fig. 30 A) corrected to 19 degrees. Loss of correction to 24 degrees in nine months (Fig. 30 B) and an additional loss to 38 degrees in the next three months (Fig. 30 C). At that time a pseudarthrosis was suspected. Four years later the patient was readmitted because of a sharp intermittent pain over entire dorsal fusion area and tenderness at the apex of the curve. There had been no further loss of correction and no attempt at recorrection was made.

29.VI.45. Repair of pseudarthrosis. A complete pseudarthrosis existed at D_{11}–D_{12}. On 25.V.48 the curve remained at 38 degrees and the patient was painless (Fig. 30 D). One would expect the loss of correction to be defined to one point in this case, it seems, however, to be distributed over the whole curve.

No. A15046 female born 13.VIII.30
Idiopathic scoliosis
Spine fusion D_{10}-L_3 2.XII.42

Original curve D_{10}–L_1–L_3, 63 degrees standing (Fig. 31 A) corrected to 30 degrees. At the first plaster change the curve measured 35 degrees (Fig. 31 B) and ten months after the operation 15 degrees of the correction were lost (Fig. 31 C). In the next four months an additional loss of 13 degrees occurred so the curve had relapsed to nearly the original deformity. 2.III.44 patient readmitted and the curve corrected again to 30 degrees.

1.V.44. Repair of pseudarthrosis and addition of L_4 to the fusion. The fusion mass appeared continuous and of good consistency except at D_{11}–D_{12} where there was fibrous union with motion easily demonstrated in this area. The patient gradually lost practically all correction again. 6.IV.48 the

curve measured 60 degrees (Fig. 31 D). The loss of correction appeared here almost exclusively at D_{11}–D_{12} and D_{12}–L_1.

It might have been better to extend the fusion all the way down to the sacrum to secure a better permanent result but only if the upper compensatory curve were rather mobile and capable of straightening out a

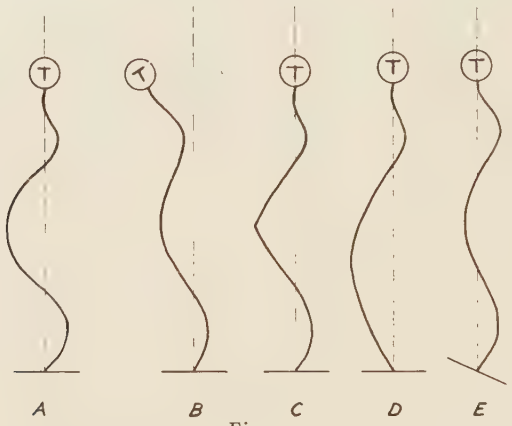


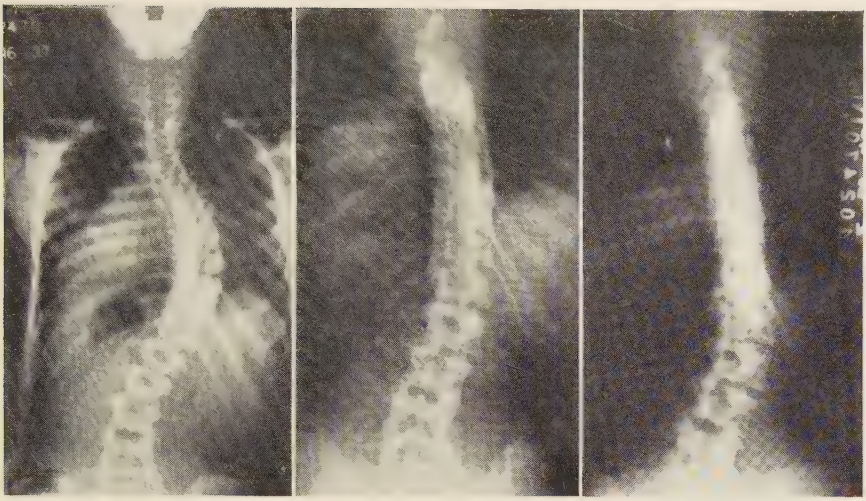
Fig. 32.

good deal. But in case of a rigid upper curve, had the fusion been extended to the sacrum and remained solid throughout, the patient might have been thrown out of balance. As it is, the patient is well balanced despite a considerable deformity.

When correcting a primary curve the compensatory curves must be taken into account. If they are so mobile that they can be straightened out completely, the primary curve can be corrected to 0 degrees, if possible, without any harm. When it is fused, the patient will be well balanced with pelvis and shoulders level and the head in the midline. If the compensatory curves, however, are rigid the correction must be carried out only to the extent that the compensatory curves will straighten out correspondingly. Therefore the correction of the primary curve is often limited, not only by the impossibility of effecting a further correction but also by the failure of the adjoining segments of the spine to compensate.

The principal aim is not to straighten out the primary curve, regardless of other factors concerned, but to acquire a trunk as well balanced as possible with the straightest possible spine. However, the body balance comes first, the straightness of the spine second.

If the correction of the primary curve is carried further than the compensatory curves will allow (Fig. 32 A–B), one of three things will happen:



A B C

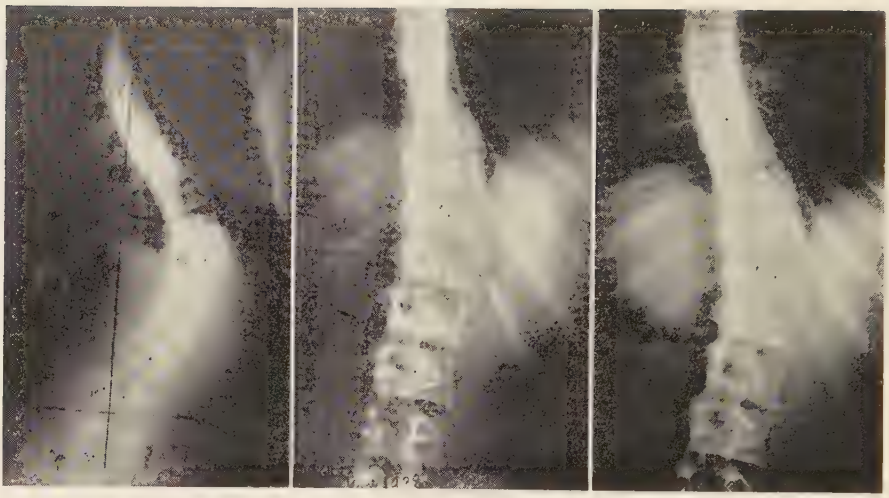
Fig. 33.

1) The fusion will break (Fig. 32 C).
2) One of the compensatory curves will reverse itself, the primary curve extend farther to one end and thereby increase. This usually takes place with the lower compensatory curve, the upper being the more rigid one (Fig. 32 D).
3) The patient will regain balance by tilting the pelvis (Fig. 32 E).

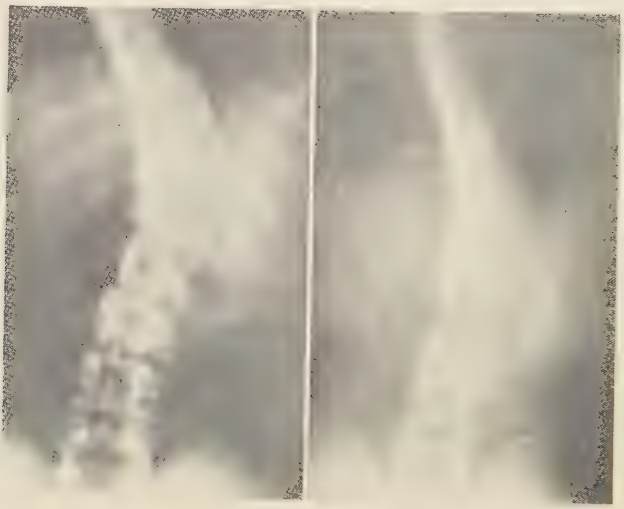
No. 205009 female born 29.X.28.
Spine fusion D_8-L_1 17.XI.37
D_3-D_8 12. I.38

Original curve D_5–D_9–L_1, 43 degrees standing (Fig. 33 A), corrected to 15 degrees. In October 1938 after the last plaster jacket had been discarded, the lumbar compensatory curve was 0 degrees, the upper one unchanged. In 1942 the lumbar curve was reversed, L_2–L_3 were added to the primary curve (Fig. 33 B) and in 1948 L_4 was also added to the original curve which in its present form is 22 degrees (Fig. 33 C). In the fused area no loss of correction had taken place. The upper curve had not straightened out and this failure of compensation was made up for by reversing the lower curve.

No. 206592 male born 14.V.24.
Idiopathic scoliosis
Spine fusion D_{11}-L_3 2.III.38
D_7-L_{11} 30.III.38



A B C



D E

Fig. 34.

Original curve D_8–D_{12}–L_3, 54 degrees standing (Fig. 34 A) corrected to 21 degrees. At the first plaster change all the correction was maintained (Fig. 34 B). Five months later he had lost 11 degrees of correction (Fig. 34 C) and in the next four months an additional 10 degrees were lost (Fig. 34 D). The loss of correction appeared to be at D_{11}–D_{12} and D_{12}–L_1. The curve was corrected again to 27 degrees.

On 19.V.39 the suspected area was explored. At what was thought

to be the level of D_{12}, a weak area was found in the fusion. No motion could be detected but the line across the fusion was composed of immature bone. There was no further loss of correction. On 9.IV.48 (Fig. 34 E) the curve measured 30 degrees maintaining a correction of 24 degrees from the original curve and losing 9 degrees from the maximal correction obtained, which is about the average loss of all curves.

This is a case of delayed healing which is for practical purposes equivalent to a pseudarthrosis. After reinforcing the weak area there was no further tendency to lose correction.

The loss of correction takes place:

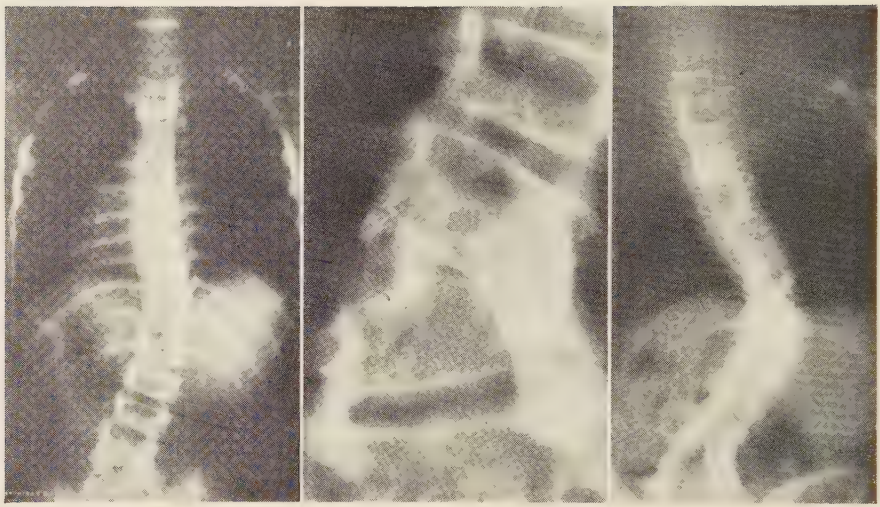
1) To some extent in most curves while the fusion area is maturing (this loss is about 10 degrees on the average).
2) Through a pseudarthrosis sustained either by failure of healing at a certain spot of the fusion or by a fracture of an already healed fusion plate.
3) Through a weak area caused by a delayed healing. These cases lose correction very much the same way as do pseudarthroses.
4) Through an extension of a primary curve. In cases of over-correction one of the compensatory curves, usually the lower one, may be reversed and become added to the original curve.

There were two patients in whom the deformity increased. One was a case of a hemivertebra, the other had thoracogenic scoliosis.

The hemivertebra case (No. 193999) was a girl born 6.V.28 admitted to the hospital 10.X.36. Ten months previously a school teacher had noticed that the patient's spine was curved. X-ray examination revealed a lumbar hemivertebra, the fourth lumbar being present only as a wedge on the left side, the right half being absent. There was a posterior defect of L_2 and D_{11}. There was a rather sharp lumbar curve L_2–L_4–S_1 measuring 30 degrees standing and 22 degrees lying and a longer dorso-lumbar one D_8–D_{11}-L_2 measuring 27 degrees standing and 20 degrees lying (Fig. 35 A lying position).

9.XI.36 removal of body of hemivertebra. "There was a wedgeshaped hemivertebra on the left side, between the bodies of the third and fourth lumbar. This really represented the fourth lumbar vertebra, the right side of which had failed to develop".

25.XI.36 the arch of the hemivertebra was removed. Three weeks later a wedging jacket was applied with the intention of correcting the lower curve. However, practically no correction was obtained beyond the lying position, the curve measuring 20 degrees at the time of operation.



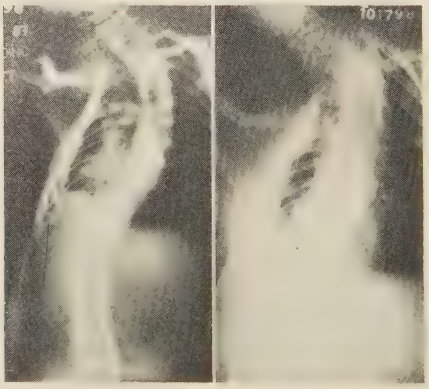
A B C

Fig. 35.

8.I.37 spine fusion L_2-S_1 reinforced with tibial chips.

Fig. 35 B shows the lower lumbar spine seven months after the fusion operation. The gap left by the removal of the hemivertebra is seen. There has been no change in the relation of the third and fourth lumbar.

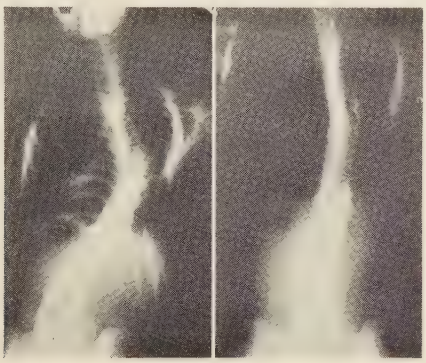
10.XI.38 the patient was readmitted as the dorso-lumbar curve had increased. Only slight correction was effected and on 19.XII.38 D_{11}–L_2 were fused, the fusion now extending from D_{11} to the sacrum. In the next twenty months the curve gradually increased to 45 degrees, since then



A B

Fig. 36.

there has been no further increase in the deformity. 12.II.48 the upper and lower curves measured 45 degrees and 25 degrees respectively (Fig. 35 C). The patient stands with shoulders level, pelvis tilted to the right by bending the right knee. When the patient stands with both knees straight, the trunk is tilted slightly to the left and forward. No tenderness of the fusion area, moderate posterior rib deformity and lumbar kyphosis. The pelvic tilt is caused by the failure of the upper segment of the spine to compensate



A B

Fig. 37.

the increase in the dorso-lumbar curve, the lower segment being solidly fused is unable to afford any compensation.

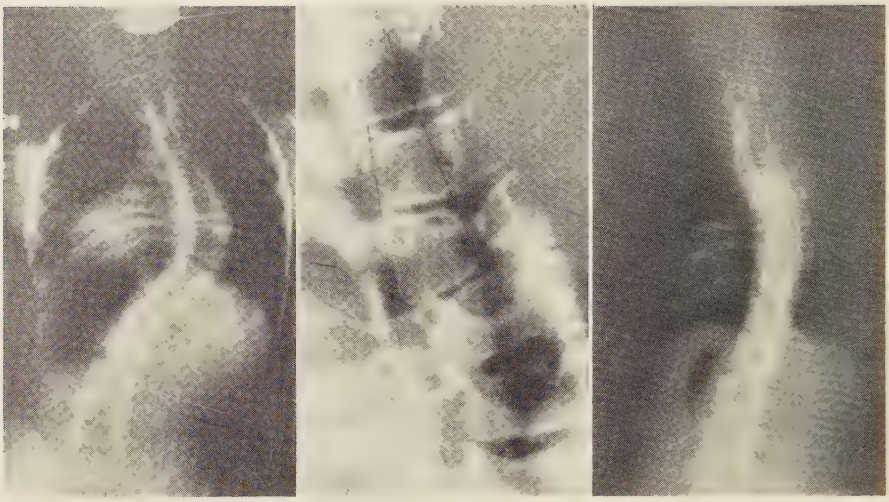
The other case in which the deformity increased had a thoracogenic scoliosis probably following an empyema of the left pleural cavity.

No. 203796, a boy born 27.II.27, was admitted to the hospital on 11.IX.37. He had an attack of pneumonia at the age of three years and was severely ill for a long time. Following the illness it was noticed that his spine was beginning to deform. The deformity had been progressively increasing.

There was a cervico-dorsal curve, C_6–D_5–D_{11}, measuring 50 degrees standing (Fig. 36 A) and 46 degrees lying, corrected to 40 degrees prior to fusion.

Spine fusion	D_8-D_{12}	3. XI.37
	D_3-D_8	26. XI.37
	C_6-D_3	17.XII.37

The curve gradually lost correction, two years later it was 52 degrees and when last seen 26.II.46 it had further increased. The lower part of the fusion area maintained correction but in the upper end, at the level of D_1, there was an angulation, the main curve now being C_6–D_2–D_7, and measuring 65 degrees (Fig. 36 B).



A B C

Fig. 38.

The only other case of thoracogenic scoliosis is interesting in so far as it corroborates the findings of Wenger (172) regarding the importance of the transverse processes for the stability of the spine.

No. 222408, a boy born 18.II.33, developed right pneumonia at the age of one year which developed into an empyema. He underwent numerous surgical procedures for drainage of the empyema cavity, six ribs were resected at various times and hospitals.

His mother noticed a curvature of the spine and brought him to the clinic 11.IV.39. The deformity increased during two years of observation and he was admitted to the hospital on 24.III.41 with a right curve D_5-D_8-D_{12} measuring 36 degrees (Fig. 37 A). The empyema cavity had been quiet for about three years. The curve was corrected to 18 degrees.

Spine fusion	D_8-D_{12}	30.IV.41
	D_4-D_8	23. V.41

The patient maintained the correction. On 20.V.46 the curve measured 20 degrees (Fig. 37 B). On 15.I.48 there had been no further loss of correction.

This patient was not through the period of vertebral growth when last examined being one month short of fifteen years and may therefore still lose correction, but in view of the fact that he has lost no correction in the seven years from eight to fifteen, any appreciable increase of the deformity is unlikely.

An empyema scoliosis is always concave to the diseased side. If this curve had been caused by the empyema it would have been convex to the left side. However, the ninth and the tenth ribs on the right had been resected close to the spine, the ninth right transverse process entirely removed and the tenth partially. This scoliosis is, therefore, a post-thoracoplasty deformity and not one due to an empyema. In fact this radical rib resection with removal of the transverse process may have reversed an already beginning left empyema curve.

No. 210554, a girl born 15.IX.29, represents a congenital scoliosis with several deformed vertebrae but none of them a hemivertebra. She was admitted to the hospital on 28.IX.38 with a right curve D_4–D_9 D_{12} measuring 53 degrees standing, 45 degrees lying. X-ray examination revealed a deformity of D_6 to D_{10}, the vertebral bodies of D_7 to D_{10} being low and wedgeshaped (Fig. 38 A). There appeared to be a cleft in the body of D_6 (Fig. 38 B). There was a spina bifida of L_4 and L_5. The curve was corrected to 30 degrees.

Spine fusion	D_6-D_{12}	21. XI.38
	D_3-D_6	12.XII.38

The patient maintained all the correction. Nine and one half years later (11.V.48) the curve measured 30 degrees (Fig. 38 C) the deformed vertebral bodies had improved in form especially the sixth dorsal which looked fairly normal.

END RESULTS

Of the 208 cases of scoliosis operated on from January 1st 1936 to December 31st 1942, 142 had a follow-up study of five years or more. 108 patients were seen by myself in the latter half of 1947 and in 1948. The follow-up data of the remaining thirty-four were taken from the records.

Preoperative Roentgenograms taken a short time before therapy was instituted were available on every patient. However, not all of them had been X-rayed at that time both in the erect and supine position so that a comparison of the standing and lying curve could not be made in all cases. The amount of correction was determined by X-rays, the last Roentgenogram being taken a day or two prior to surgery. Following the fusion operation, Roentgenograms were made at three months intervals for nine months and after that time when deemed necessary.

Of the 142 cases, three were operated on again in 1947 and one in 1948, leaving 138 cases on which the end result study is based.

According to etiology and localization of the primary curve, the cases were classified as follows:

	Idiopathic	Paralytic	Congenit.	Thoracogen.	
Dorsal	55	7	1	2	65
Dorso-lumbar	57	8	3		68
Double primary	4	1			5
	116	16	4	2	138

Four were congenital, due to a hemivertebra in three cases and to deformed vertebrae in one case. One followed an empyema and one developed after a thoracoplasty which was performed to obliterate an empyema cavity.

In two cases no correction was attempted. Only two showed an increase in the curvature compared with the standing view prior to surgery. Seven cases maintained a correction of 5 degrees or less. Five cases maintained a correction of 10 per cent or less compared with the original curve

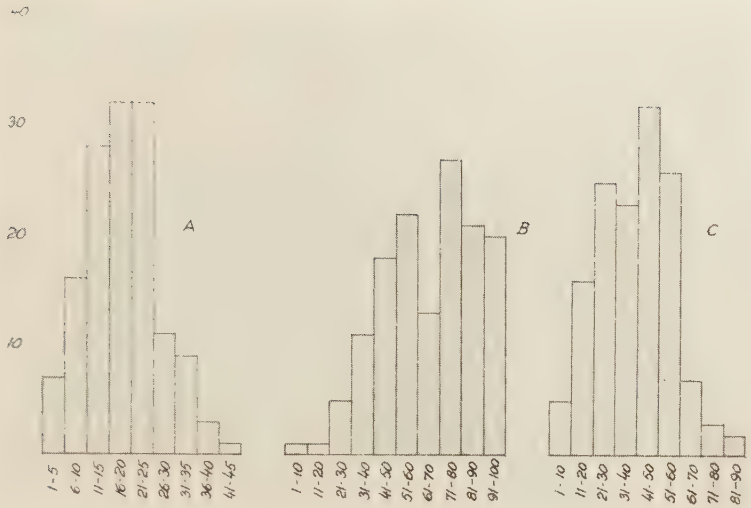


Fig. 39.

Correction maintained in 139 curves five years or more after operation. A. shows the maintained correction in degrees, B. in per cent of the obtained correction and C. in per cent of the original curve. In eighty-eight curves (63.3 per cent) more than 15 degrees of correction was maintained. 103 curves (74.1 per cent) maintained more than 50 per cent of the obtained correction. In ninety-three curves (66.9 per cent) more correction than 30 per cent of the original curve was maintained.

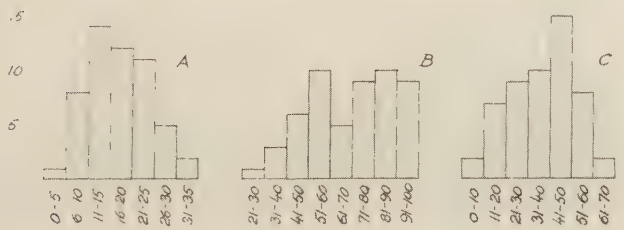


Fig. 40.

Correction maintained five years or more after operation. Dorsal idiopathic curves except the case where pseudarthrosis occurred. Fifty-three cases. A. shows the maintained correction in degrees, B. in per cent of the obtained correction and C. in per cent of the original curve. Thirty patients (56.6 per cent) maintained more than 15 degrees correction, forty-three patients (81.1 per cent) maintained more than 50 per cent of the obtained correction and thirty-five patients maintained more correction than 30 per cent of the original curve.

in the erect position. There were 134 patients presenting 139 curves (five patients had double primary curves) who retained more or less correction or at least remained stationary. Fig. 39 shows the amount of correction maintained.

In eighty-eight curves (63.3 per cent) more than 15 degrees of cor-

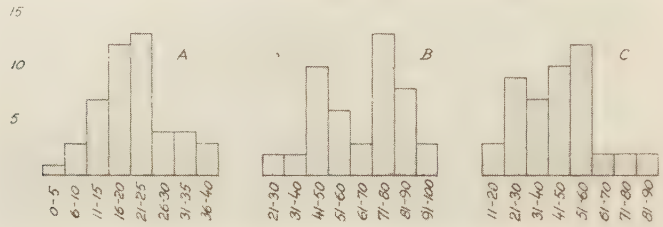


Fig. 41.

Correction maintained five years or more after operation. Dorso-lumbar idiopathic curves, except the cases where pseudarthrosis occurred. Forty-seven cases. A. shows the maintained correction in degrees, B. in per cent of the obtained correction and C. in per cent of the original curve. Thirty-six patients (76.6 per cent) maintained more than 15 degrees. Thirty-four patients (72.3 per cent) maintained more than 50 per cent of the obtained correction and thirty-five patients (74.5 per cent) maintained more correction than 30 per cent of the original curve.

rection was maintained and more than 30 per cent of correction compared with the original curve was preserved in ninety-three cases (66.9 per cent). One-half maintained more than 40 per cent correction.

In nine cases (6.5 per cent) none of the correction obtained was lost and 103 patients (74.1 per cent) maintained more than one-half of the correction produced in the wedging jacket. About one-half of the curves (68 cases, 48.9 per cent) preserved more than 70 per cent of the preoperative correction.

Fig. 40 shows the corresponding figures for the dorsal idiopathic curves, pseudarthrosis excepted. There are relatively fewer cases with more than 15 degrees correction (56.6 per cent) because of the rigidity of the dorsal spine. On the other hand the obtained correction is somewhat better preserved, more than 50 per cent of the correction being maintained in 81.1 per cent of the cases. The retained correction compared with the original curve is the average figure, thirty-five patients (66 per cent) maintaining more than 30 per cent correction.

Fig. 41 shows the dorso-lumbar curves. A correction of more than 15 degrees was maintained in 76.6 per cent bearing witness to the greater mobility of the lower segments of the spine as well as the fact that three

out of every four cases (74.5 per cent) retained more than 30 per cent correction compared with the original curve.

The preservation of the obtained correction was the average, 72.3 per cent maintaining more than one-half of the maximum correction.

The loss of correction is shown in Fig. 42 for all the curves. Ninety-one

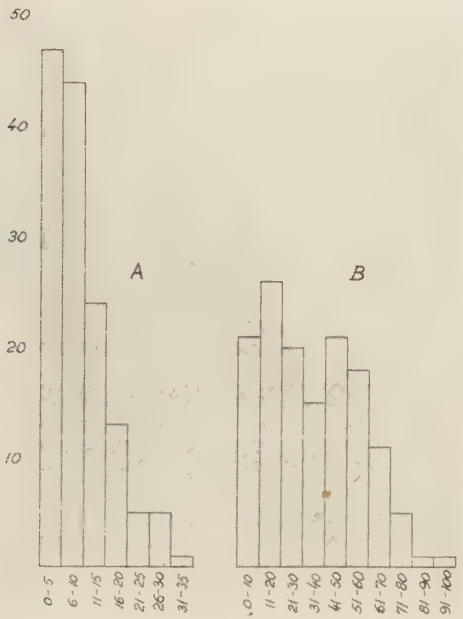


Fig. 42.

Loss of correction in five years or more (139 curves). A. loss in degrees. B. loss in per cent of obtained correction. Ninety-one (65.5 per cent) lost 10 degrees or less. Thirty-six (25.9 per cent) lost more than 50 per cent of the obtained correction.

(65 per cent) lost 10 degrees or less. Of the dorsal idiopathic curves, about three-fourths (73.5 per cent) lost 10 degrees or less (Fig. 43), whereas in the dorso-lumbar idiopathic curves only 63.6 per cent did not lose more than 10 degrees (Fig. 44).

The average correction maintained in sixty-five dorsal curves was 15.88 degrees and in sixty-eight dorso-lumbar cases 19.89 degrees. The average correction maintained in 143 curves was 17.99 degrees. In these figures all the curves are included, including the two that progressed and the two cases that were not corrected.

The correction by the forcible redressement of the wedging jacket is, of course, considerably less than the whole correction, the spine straightens out about 9 degrees on the average by changing position from erect to

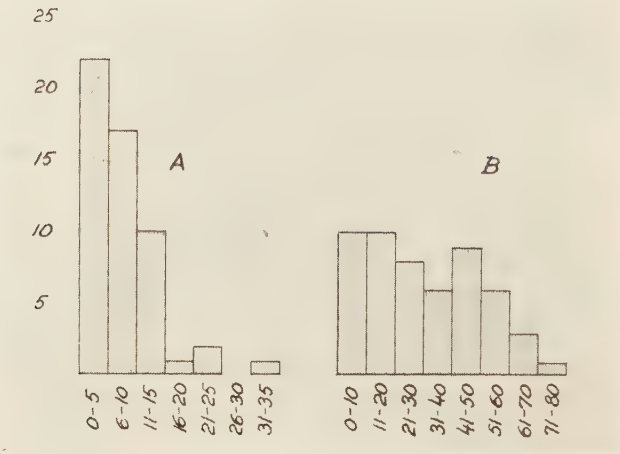


Fig. 43.

Loss of correction in five years or more. Dorsal idiopathic curves, except the case where pseudarthrosis occurred. Fifty-three cases. A. is the loss of correction in degrees, B. the loss in per cent of the obtained correction. Thirty-nine patients (73.5 per cent) lost 10 degrees or less. Ten patients (18.9 per cent) lost more than 50 per cent of the obtained correction.

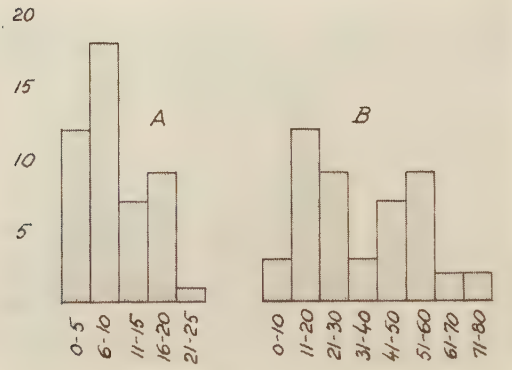


Fig. 44.

Loss of correction in five years or more. Dorso-lumbar idiopathic curves, except the cases where pseudarthrosis occurred. Forty-seven cases. A. is the loss of correction in degrees, B. is the loss in per cent of the obtained correction. Thirty patients (63.8 per cent) lost 10 degrees or less. Thirteen patients (27.7 per cent) lost more than 50 per cent of the obtained correction.

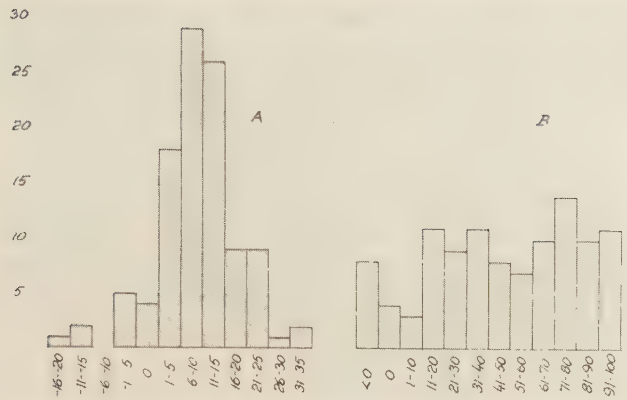


Fig. 45.

Forcible correction maintained five years or more after operation in 106 curves. Twelve (11.3 per cent) lost all correction. Fifty-two (49.5 per cent) maintained more than 50 per cent of the forcible correction obtained.

supine. 106 patients had Roentgenograms made in both the standing and lying position a short time before starting the treatment. In one case no correction was attempted and in two additional ones only the slack was taken up, the correction not being carried farther than shown on the X-ray film previously taken in the supine position. Three cases had double primary curves so that there were actually 106 corrected curves on record. The graph, Fig. 45, is computed on the basis of these cases. The follow-up Roentgenograms were all taken in the standing position. That, however, is of no consequence, the curves were all fused at the time of re-examination and incapable of changing by a change in posture. Fifty-two (49.5 per cent) or about one-half maintained more than 50 per cent of the forcible correction. Four returned to the starting point, eight lost correction beyond the original lying curve. One of them lost 19 degrees and is one of two curves in this material which increased in severity in spite of surgical treatment.

The average improvement maintained in the 109 curves from the supine position was 9.07 degrees; in forty-nine dorsal curves it was 8.01 degrees and in fifty-four dorso-lumbar it amounted to 9.70 degrees. Forty-seven (44.3 per cent) retained more than 10 degrees correction. The average loss of the forcible correction is about 10 degrees or one-half of the straightening effected by the Risser Jacket (cfr. Fig. 21).

Accordingly, in a given case one may expect to maintain one-half of the correction obtained in the wedging jacket in addition to the improvement brought about by lying down.

Risser & Ferguson (144) have shown that "increase in curvature in

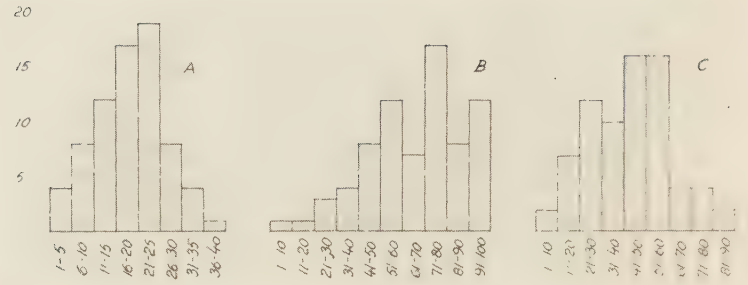


Fig. 46.

Correction maintained in patients under fourteen years at the beginning of treatment. Sixty-nine patients, seventy-three curves. A. correction maintained in degrees, B. in per cent of maximum correction and C. in per cent of the original curve. Forty-nine curves (67.1 per cent) maintained more than 15 degrees. Fifty-six curves (76.7 per cent) maintained more than one-half of the maximum correction. Fifty-two curves (71.2 per cent) maintained more correction than 30 per cent of the original standing curve.

scoliosis cases ceases when vertebral growth stops" and that, "the relation of increase of curvature to growth is not materially influenced by the etiology of the curve". They also have proved that growth in vertebral height ceases in girls at or before the age of sixteen and in boys at or before the age of seventeen years. Therefore, no substantial increase in the deformity and probably no increase at all is to be expected in males after the seventeenth and in females after the sixteenth year of age. Many of the cases reported with good results have been beyond that age when the treatment was undertaken and some authors prefer to wait until cessation of growth before instituting surgical therapy. These cases prove the validity of the procedure only in such cases where a permanent straightening of the spine has been attained. On the other hand, they are of no value in proving that this particular treatment is capable of arresting a curvature which is progressing.

In seventy-seven of the cases followed for five years or more, treatment was begun before the patient was fourteen years old. Three of these patients had not finished their vertebral growth at the end of this study; two had been reoperated recently and are not included as end results, in one case no correction was attempted prior to surgery and in two cases the deformity increased. Four of the patients had double primary curves. That leaves sixty-nine patients with seventy-three curves, all of which maintained more or less correction or at least remained stationary. Fig. 46 shows the amount of correction preserved. Seven cases maintained all the correction obtained and three-fourths of the cases (76.71 per cent) main-

tained more than one-half of it. On comparing Fig. 46 with Fig. 39 which shows the corresponding figures for all the curves irrespective of age when fused, it is evident that they are very similar. However, the younger class seems to maintain slightly more correction both absolutely and relatively. The difference is easily explained, either by the limited number of cases or by the fact that the younger spines are more correctible than the older ones. All the patients, except the three previously mentioned, were past the period of vertebral growth. The average age when last seen was nineteen years. The follow-up time ranged from five to twelve years.

The average correction maintained, including the two curves that increased in severity, was 18.05 degrees, which is practically the same figure as the over-all average.

However, the scoliotic deformity is a more complex matter than merely a lateral deviation of the vertebral column, the other factors, rib deformity, prominence of one hip, etc., must be taken into account. In all the patients operated on, an appreciable lateral curvature of the spine was clinically manifest and only one showed absence of rib deformity (Table 7).

TABLE 7

Clinical signs and symptoms in 138 patients before operation and five or more years afterwards.

	Curvature	Rib deform.	High should.	Prom. hip	Shift of trunk	Pelvic tilt	Pain	Fatigue
pre op.	138	137	96	133	130	18	31	13
post op. ...	89	90	33	59	17	17	9	7

Postoperatively, the back looked straight in forty-nine cases, and in forty-eight cases no rib deformity was apparent. Shift of the trunk was present in 130 cases before the treatment and afterwards in only seventeen, indicating the improvement in body balance. This improvement was observed in many cases which showed only moderate correction of the lateral curve. The same is true of the hip prominence.

Thirty-one patients complained of pain in the back when admitted to the hospital for surgical treatment. In some cases the pain occurred only occasionally and was mild, but in a few patients it was rather severe. In the oldest patients the pain was the main indication for the fusion. The youngest patient complaining of pain was eleven years old, but the majority of the patients eighteen years and older had more or less pain or ache in the back on exertion.

Eight patients tired easily but had no pain and five of the patients having pain also complained of fatigue.

Postoperatively, nine patients admitted pain, eight had occasional low back trouble and seven were easily fatigued.

Two patients were not working, both had been in State Hospitals, one for extreme nervousness, the other for dementia praecox of the paranoid type. 106 were fully active, either working full time or attending school and participating actively in sports. Of the remaining thirty, no direct mention was made in the records of their activities. However, it may be assumed that they have been leading normal lives as it is most probable that the contrary would have been mentioned had it been the case. Of the 107 females, fifteen had married and had seven children.

An attempt was made to evaluate the results on the basis of the factors shown in Table 7. Such an estimate must necessarily be subjective to a considerable degree, the only factor actually measured being the lateral curve, which can easily be measured on the Roentgenogram. The other factors of the deformity, although secondary to and dependent on the lateral curvature, need not be proportionate to the degree of the lateral deformity of the spine. If they were, the severity and localization of the curve would be an exact indicator of these deformities and the examiner's subjective error would be eliminated. Pain and fatigue are purely subjective symptoms and are not accessible to measurement. Various authors have attempted to measure the other factors, especially the rib deformity and some have invented elaborate apparatus to attain this end, but mostly with only moderate success.

The results of the evaluation are shown in Table 8.

TABLE 8

Composite Estimate of Results in 138 cases.

	Mild 25 degrees and less	Moderate 26-50 degrees	Severe over 50 degrees	Total percentage
Excellent	3	50	16	50.00
Good	2	15	17	24.64
Fair		4	22	18.84
Poor		4	5	6.52
Total	5	73	60	100.00

Smith et al. (162) in reviewing 257 cases of comparable material treated by the same method arrived at the following figures (Table 9).

On comparing these two tables, worked out by different observers, the conformity between the figures is evident. In fact, they are so similar

TABLE 9

	Mild 25 degrees and less	Moderate 25-50 degrees	Severe over 50 degrees	Total percentage
Excellent	9	87	36	51.3
Good	3	23	47	28.4
Fair	2	13	25	15.6
Poor	0	2	10	4.7
Total	14	125	118	100.0

that they may be taken as a fairly accurate indicator of the effectiveness of the treatment discussed in this paper.

There were nine cases which were termed as poor and may be considered as failures:

I) No. 186819 female born 6.VII.25.
Paralytic scoliosis.

The patient had a left curve C_6–D_5–D_9, measuring 27 degrees standing and a right one D_9–D_{12}–L_3 measuring 19 degrees.

The upper curve was fused in two stages

25. V.38 D_4–D_{10} and
17.VI.38 C_6–D_4

The curve was corrected to 8 degrees prior to the operation. Eight years later the upper curve was 14 degrees, the lower curve, however, had increased to 37 degrees. The left hip had become markedly prominent and the trunk shifted to the right. Correction of the lower curve and extension of the fusion were advised but the patient refused.

II) No. 192208 female born 27.IV.25.
Idiopathic scoliosis.

The patient had been treated elsewhere with series of plaster jackets and with spine fusion two and one-half years before she was admitted to the hospital. The curve was increasing. There was a right curve D_3–D_6–D_{12} measuring 64 degrees standing and 58 degrees lying. The upper limit of the previous fusion was D_6.

The curve was corrected to 48 degrees and a two stage fusion done

29. I.37 D_3–D_6
19.II.37 C_7–D_3

She was last seen seven and one half years later. The curve measured 56 degrees. There was a shift of the trunk to the right, right posterior rib deformity, prominence of the left hip and occasional backache.

III) No. 193999 female born 6.V.28 see page 65.

IV) No. 203796 male born 27.II.27 see page 67.

V) No. 239771 female born 18.VI.28.

The patient was admitted to the hospital 11.IX.41. Curvature of the back was first noticed when the patient was two years old. The curve had been progressing and for one year prior to admission she had had pain in both flanks, occasionally in the abdomen and over the left side of the thorax posteriorly. D_{10} was a hemivertebra, the right half of which had failed to develop. Left curve D_7–D_{11}–L_1 measuring 45 degrees both standing and lying. The curve was corrected to 10 degrees and fused in two stages

14. XI.41 D_{10}–L_1 and
8.XII.41 D_8–D_{10}

On 4.I.45 there was marked tenderness in the region of D_{10}–D_{11} and laminograms disclosed a break in the continuity of the fusion mass in that region. The curve measured 35 degrees. There had been no loss of correction after the first three months.

16.IV.45 repair of pseudarthrosis. A transverse pseudarthrosis across the entire fusion area was found and motion easily demonstrated.

2.XII.47 increasing pain in the spine and flanks and tenderness in the D_{11} area made the diagnosis of a pseudarthrosis probable, although no break in the fusion could be seen on the Roentgenograms. An exploration of the fusion was advised. The curve remained stationary.

VI) No. 219793 female born 10.VI.03.
Idiopathic scoliosis.

The patient has had a severe deformity of the spine as long as she can remember and has had pain in the back. Lately the pain has been increasing. Left curve D_8 D_{12} L_3, measuring 115 degrees standing and 102 degrees lying. No correction attempted.

Spine fusion 20.V.40 D_6–D_{11}

Solid natural fusion was found D_{11} L_2. Six months later a pseudarthrosis was suspected at D_{10}–D_{11}.

2.XII.40 repair of pseudarthrosis. Fusion of L_2–L_3. An irregular pseudarthrosis was found at D_9–D_{10}. The fusion was to have extended to the sacrum, but following a transfusion preparatory to the second stage, the patient had a severe reaction with anuria. She improved following conservative treatment but it was decided to do no further surgery at present. She was last seen 24.X.46 when she complained of pain in the back, chiefly radiating in nature. Roentgenograms were ordered and she was to return in two weeks, but did not report.

VII) No. 233456 male born 9.IV.26.

The patient was admitted to the hospital 23.IX.40. The deformity was first noticed about two years earlier. At times he has dull ache in lower dorsal area when sitting any length of time. Left curve D_7–D_{10}–D_{13} measuring 51 degrees standing, 46 degrees lying, corrected to 34 degrees.

Spine fusion 6.XI.40 D_9–D_{13}
27.XI.40 D_5–D_9 and D_{13}–L_1

Loss of correction in the first year to 44 degrees. 9.III.48 the curve measured 47 degrees. There was a marked left curve with considerable rib deformity and some shift of the trunk to the left. There was no pain or fatigue. He was working full time.

VIII) No. A 6850 female born 6.VIII.28.
Idiopathic scoliosis.

Right curve D_6–D_9–D_{12} measuring 60 degrees standing and 52 degrees lying, corrected to 30 degrees.

Spine fusion 8.IV.42 D_6–D_{11}

The curve actually seems to have extended to L_1 and, therefore, the fusion was at least two vertebrae short of including the minimal segment to be fused. The patient lost correction primarily at D_{11}–D_{12} and D_{12}–L_1 to 55 degrees. In this case the fusion ought to have been extended to L_4 or at least to L_3 to maintain good balance of the trunk.

When last seen 6.IV.48 there was no pain or fatigue. The left hip was very prominent. Considerable right curvature with marked rib deformity. Trunk shifted to the right.

IX) No. A 15046 female born 13.VIII.30 see page 61.

The cause of failure in four cases (I, III, VI and VIII) may be found in too short a segment being fused and this is probably true

for a fifth case (IX) also. In one case (V) the likelihood of a pseudarthrosis is great. In another case (IV) most of the correction loss occurs through an angulation in the upper part of the fusion area. A pseudarthrosis might have been present here although not detected. Practically all of the loss (10 degrees) in one case (VII) took place in the first year. This loss could possibly be due to pseudarthrosis or delayed consolidation of the fusion plate; on the other hand the total loss of correction (13 degrees) is only slightly more than the average loss. To maintain an appreciable correction in this case a much greater initial correction would have had to be effected. The same is true for case II. The loss of correction was only 8 degrees, however, the secondary deformities had not improved, the body balance was rather poor and there were occasional backaches.

SUMMARY

I.

In the first chapter the etiology is shortly discussed. Muscular imbalance is considered to be a cause in a number of cases, occasionally in the form of hypertrophy of certain muscles, but much more often paralysis or paresis of muscle groups cause a lateral curvature of the spine.

It is related how some pathological conditions of the rib cage and thoracic organs may cause scoliosis, the most common being thoracoplasty and retraction of a post empyema scar formation. The etiology of the most common lateral curvature, the idiopathic scoliosis, is still unknown. Several hypotheses regarding the etiology are mentioned. Rickets is considered an unlikely cause of a lateral deviation of the spine.

II.

In the second chapter some aspects of the pathology are considered. Attention is called to rotation and wedging of individual vertebrae as well as rotation of segments of the spinal column. Compensation of the primary curve is discussed:

a) by additional curves
b) by tilting the pelvis.

Accessory deformities are remarked upon such as rib deformity, prominence of one hip, displacement of the trunk. Mention is made of complications, for instance pulmono-cardiac failure, spinal cord compression, pain, fatigue.

III.

The third chapter presents a review of some of the surgical procedures that have been used during the last century in the treatment of scoliosis. A few operations on the soft parts are brought to attention, starting with

Guerin's myotomies. Secondly operations on the ribs are recalled. A short summary of operations on the spine follows such as excision of a hemivertebra, transversectomy and resection of the articulating processes and lastly the ankylosing operations of the spine are discussed.

IV.

In the fourth chapter the material is presented upon which this paper is based. In the seven year period from 1936 to 1942 208 new cases of scoliosis were operated on in the New York Orthopedic Hospital. The distribution of the curves is shown according to:

1) etiology
2) sex
3) localization
4) age
   a) when discovered
   b) when operated on.

V.

In the fifth chapter the treatment of the previously mentioned 208 cases is described. At first the method employed in measuring the curvatures and its accuracy is discussed. A description of the correction and selection of fusion area follows. Lastly the operation itself is described.

VI.

In the sixth chapter loss of correction in the straightened and fused spine is discussed. The different causes of a loss of correction are mentioned (pseudarthrosis, delayed healing, extension of a primary curve). The results of overcorrection are brought to attention.

A mention is made of the fact that the incidence of pseudarthrosis increases along with increased mobility of the spine, being higher in the lower segments of the vertebral column and in paralytic scoliosis.

The different types of loss of correction are illustrated by a few case histories.

VII.

In the last chapter the end results in 138 cases followed for five or more years are studied.

In nine cases none of the obtained correction was lost. In two cases

the curvature increased compared with the standing view prior to surgery. Seven cases maintained 5 degrees or less of correction and in two cases no correction was attempted.

The average maintained correction was 18 degrees. In a given case one may expect to retain one-half of the correction obtained in the wedging jacket in addition to the correction brought about by changing position from standing to lying.

Comparison of the maintained correction in all the cases and in those still growing at the time of operation gives approximately identical results.

The accessory deformities improved in most cases, the improvement being most pronounced in the body balance.

Lastly nine cases considered poor results are discussed.

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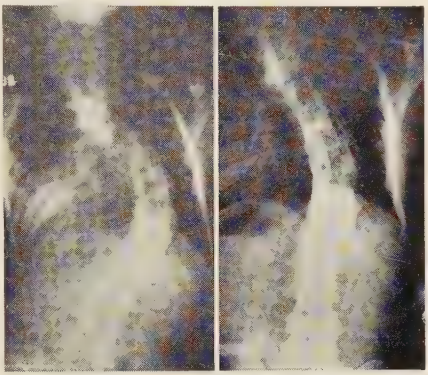
CASE HISTORIES

The Roentgenograms are looked at from behind, the back of the patient facing the observer.

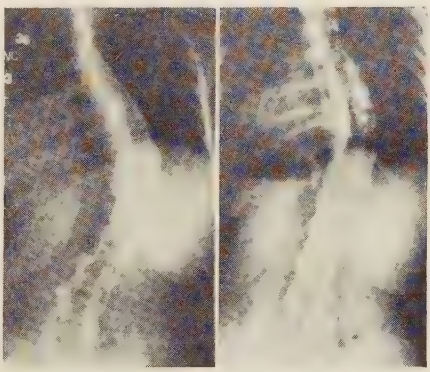
The preoperative photographs were taken shortly before treatment was commenced. The postoperative photographs were in most cases taken one and one half to two years after the operation. The patients whose photographs are reproduced here lost no correction after the photographs had been taken.

No. 63674 female born 25.III.23.
Left curve D_3–D_7–L_1, standing 85 degrees corrected to 68 degrees.
The diagnosis of a scoliosis due to a hemivertebra was made in 1925. By 1934 the curve was 64 degrees and correction and fusion were strongly advised, but refused. In March 1939 the patient returned having pain and a feeling of weakness in the back.
Spine fusion 31. V.39 D_5 D_9
23.VI.39 D_1–D_5
18.IX.39 D_9–L_1
12.XII.46. No pain in back and no tenderness. Fatigue in low back at times. Severe left curve and rib deformity. Prominent right hip. Left shoulder elevated. Curve measures 77 degrees. Posture and balance have improved and the patient is especially satisfied with the absence of pain.

No. 83662 male born 1.IV.25.
Right curve D_5–D_{11}–L_3, standing 59 degrees, lying 45 degrees, corrected to 16 degrees.
Spine fusion 6. VI.38 D_{11}–L_3
29. VI.38 D_6–D_{11}
26.VII.38 D_4–D_6
Loss of correction in six months to 35 degrees. Pseudarthrosis suspected at D_9–D_{10}. 22.III.39 exploration of fusion. Fusion found solid throughout, but with bone appearing younger at one point in the region of D_9–D_{10} than elsewhere. No motion found. Corrected before exploration to 26 degrees.
15.IV.48. Working as a sawing machine operator. No pain in back or undue fatigue. Marked right curve with considerable right posterior rib deformity. Shoulders level. Slight right pelvic tilt. No trunk shift. No tenderness of spine. Loss of correction to 45 degrees.


A 83662 B

No. 120856 female born 4.III.15.
Right curve D_7–D_{11}–L_3, standing 48 degrees, lying 35 degrees, corrected to 15 degrees.
Spine fusion 24. V.37 D_{12}–L_4
14.VI.37 D_6–D_{12}
9.V.46. For the last three years frequently some pain and sometimes tenderness below the fusion area. Mild right curve. Pelvis and shoulders level. The Roentgenogram shows localized arthritic lipping of the bodies of L_4–L_5. Curve measures 32 degrees.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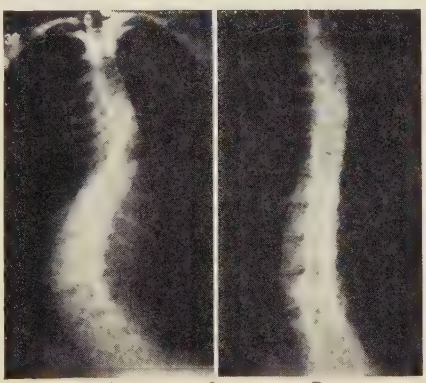
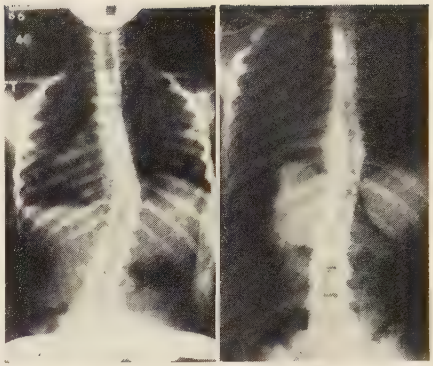
No. 136740 female born 13.VII.27.
Right curve D_5–D_8–D_{10}, standing 30 degrees, lying 26 degrees. Left curve D_{10}–L_2–L_5, standing 48 degrees, lying 30 degrees. Right curve corrected to 9 degrees.
Spine fusion 23.III.38 D_8–D_{11}
15.IV.38 D_4–D_8
The right hip continued to be prominent. The lumbar curve did not straighten out. It was decided that this was probably due to an unstable fifth lumbar vertebra and a possible primary element in the lumbar curve.
Spine fusion 6.III.40 L_4–S_1
The lumbar curve still did not straighten out.
Left curve corrected to 10 degrees.
Spine fusion 10.IV.42 D_{11}–L_3
Loss of correction in three months to 25 degrees. Pseudarthrosis suspected at L_1–L_2 and L_2–L_3.
27.VII.42 Repair of pseudarthrosis.
There was an irregular pseudarthrosis across each of the three joints D_{11}–D_{12}, D_{12}–L_1 and L_1–L_2.
19.II.48. Works as a bookkeeper. There is some pain in the lumbar spine, mainly when standing and walking for any length of time. Some tenderness at L_3–L_4. Slight pelvic tilt to the left. Shoulders level. Right hip prominent. Right curve 14 degrees, left curve 25 degrees.

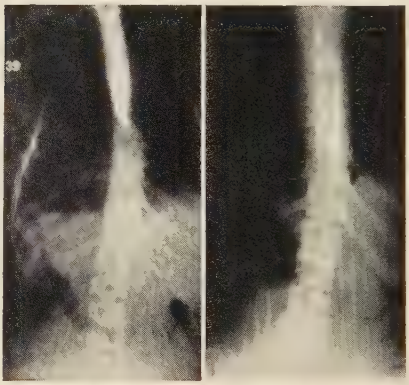

A 136740 B

No. 142700 female born 1.IX.29.
Poliomyelitis in 1931.
Right curve D_8–D_{11}–L_2, standing 24 degrees, lying 12 degrees, corrected to 0 degrees.
Spine fusion 11. XI.40 D_{10}–L_2
6.XII.40 D_6–D_{10}
29.IV.48. Wears bilateral long leg braces. Spine is straight, shoulders level. No pain or tenderness. Pat. engages in full time activities. Loss of correction to 5 degrees.



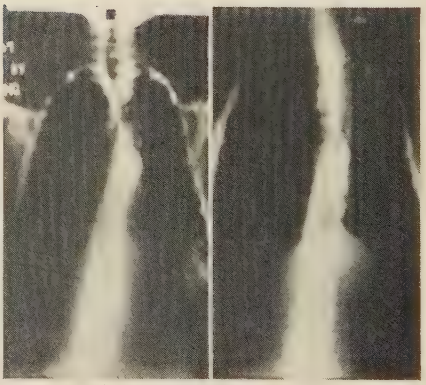
A 142700 B

No. 142762 male born 5.VIII.27.
Poliomyelitis in 1931.
Right curve D_3–D_7–D_{10}, standing 16 degrees, lying 14 degrees, corrected to 8 degrees.
Spine fusion 1.III.40 D_6–D_{11}
22.III.40 D_1–D_6
30.IV.46. Back looks straight. No pain or tenderness. The curve measures 14 degrees. It seems to have extended downwards fairly to the level of L_3.



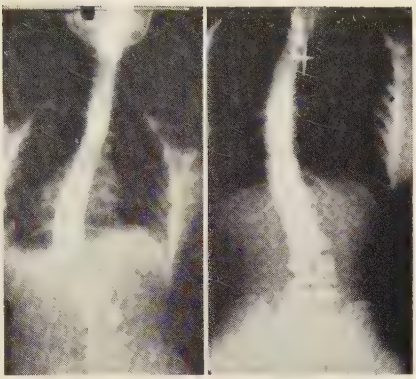
A 142762 B

No. 143680 male born 18.X.29.
Poliomyelitis at the age of two years.
Right curve D_3–D_6–D_9, standing 25 degrees, corrected to 10 degrees.
Spine fusion 18. II.38 D_6–D_{10}
13.III.38 D_3–D_6
13.V.47. No pain or tenderness. Back looks practically straight. Pelvis level. Slight elevation of right shoulder. Curve measures 20 degrees.



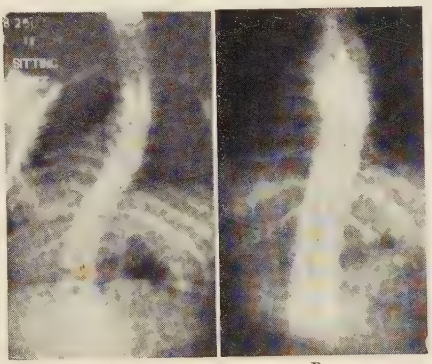
A 143680 B

No.144251 female born 30.IX.28.
Poliomyelitis in 1931.
Left curve D_7–D_{10}–L_2, standing 35 degrees, corrected to 6 degrees.
Spine fusion 17.IV.39 D_{10}–L_2
15. V.39 D_7–D_{10}
18.IX.45. No pain or tenderness. Slightest left curve. No rib deformity. Shoulders level. Curve measures 20 degrees.

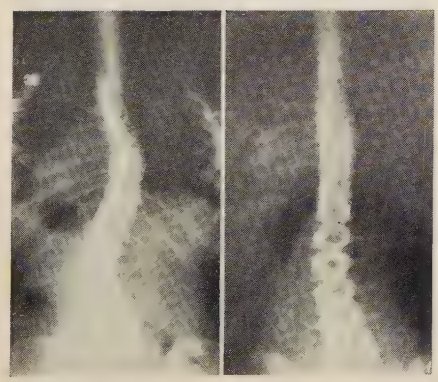


A 144251 B

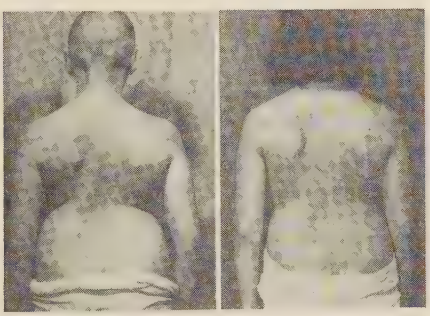
No. 145577 male born 27.III.28.
Poliomyelitis in 1931.
Left curve D_9–L_1–L_4, standing 44 degrees, lying 34 degrees, corrected to 13 degrees.
Spine fusion 14.IV.37 D_{12}–L_4
5. V.37 D_7–D_{12}
At the first plaster change a pseudarthrosis was suspected at D_{11}–D_{12}. No loss of correction.
28.VII.37. Repair of pseudarthrosis.
Definite pseudarthrosis found at D_{11}–D_{12} and a fine line pseudarthrosis at D_{10}–D_{11}.
8.IV.48. The patient walks with two crutches and long leg braces. No pain or tenderness of back. The fused area has lost no correction. The upper compensatory curve has not straightened out. The original curve measures 13 degrees.



A 145577 B

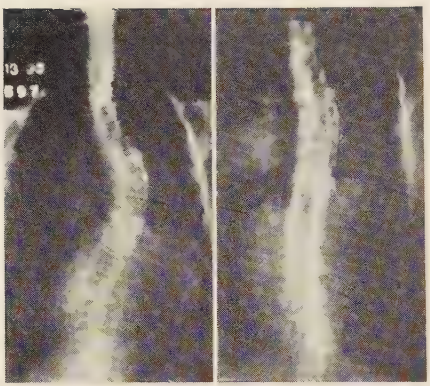


A B



C D

No. 147989 female born 15.IV.27.
Right curve D_6–D_8–D_{11}, standing 30 degrees, corrected to 10 degrees.
Spine fusion 30.III.38 D_9–D_{12}
27.IV.38 D_5–D_9
19.II.48. Is attending business school. Plays tennis without discomfort. Occasional pain in back after exertion. Spine is practically straight. No rib deformity. Slight prominence of right hip. No tenderness. Lost correction to 13 degrees in three months, no further loss of correction. The lumbar curve measuring 32 degrees before operation has straightened out to 15 degrees.



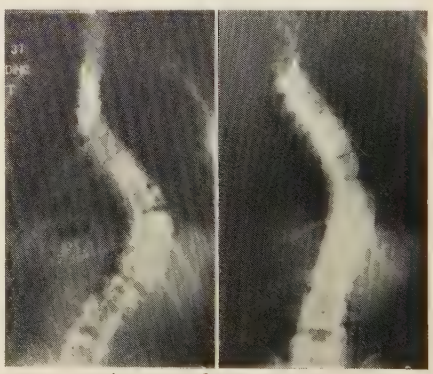
A B

C D

No. 155483 female born 26.IV.25.
Right curve D_5–D_8–L_1, standing 39 degrees, lying 31 degrees, corrected to 14 degrees.
Spine fusion 15. I.36 D_4–D_8
11.III.36 D_8–D_{11}
27.V.38 D_{11}–L_2 was added to the fusion because of extension of the curve below the original fusion area, which was at least one vertebra too short (only eleven dorsals present).
14.X.41. No pain, undue fatigue or tenderness. Back looks straight. Pelvis level. Slight elevation of left shoulder. Curve measures 27 degrees.

No. 159596 female born 2.X.25.
Poliomyelitis in 1931.
Left curve D_8–D_{12}–L_2, standing 76 degrees, lying 64 degrees, corrected to 44 degrees.
Spine fusion 17.IV.40 D_6–D_{11}
8. V.40 D_{11}–L_2
Loss of correction in one year to 63 degrees.
19.V.41. Repair of pseudarthrosis.
At the apex of the curvature, which by X-ray is D_{12}–D_{13} there was a pseudarthrosis extending completely across the fusion area. The remainder of the fusion area was found to be entirely solid. The curve was recorrected to 44 degrees prior to the repair operation.
7.VIII.46. Moderate left curve with left posterior rib prominence. Pelvis level. No pain or tenderness. Lost correction to 53 degrees in six months. Curve measures 55 degrees. Fig. 28 A and E).

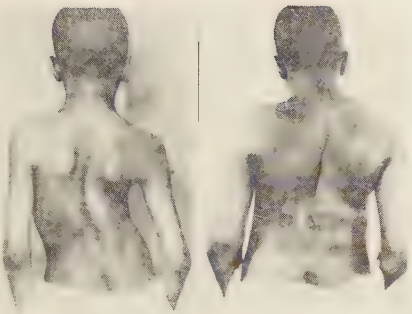
No. 169007 male born 21.VI.18.
Right curve D_8 D_{11}–L_3, standing 59 degrees, lying 47 degrees, corrected to 33 degrees.
Spine fusion 5.XI.37 D_{11}–L_3
10. I.38 D_7–D_{11}
8.IV.48. Occasional pain in the back. Slight tenderness of the lower thoracic spine. Moderate right curve with some posterior rib deformity. Shoulders and pelvis level. Loss of correction in nine months to 40 degrees. No further loss of correction.



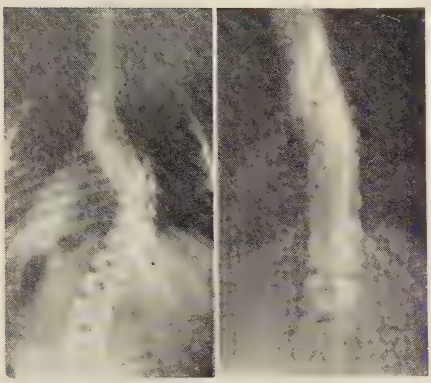
A 169007 B

No. 175100 female born 14.XI.29.
Poliomyelitis in 1932.
Right curve D_6–D_{10}–L_2, standing 51 degrees, lying 35 degrees, corrected to 22 degrees.
Spine fusion 28. I.42 D_{10}–L_1
20.II.42 D_5–D_{10}
In one and one half year gradual loss of correction to 44 degrees.
19.IV.44.Repair of pseudarthrosis.
Pseudarthrosis filled with fibrous tissue was found at about the level of D_{10}–D_{11}. Articular cartilage was present.
11.II.47. Patient has a painless spine. No further loss of correction. Curve measures 46 degrees.

No. 176068 male born 13.XII.30.
Left curve D_6–D_{11}–L_3, standing 54 degrees, lying 52 degrees, corrected to 25 degrees.
Spine fusion 10.I.40 D_8–L_3
31.I.40 D_3–D_8
19.II.48. Pelvic tilt to right. Right leg two and one half centimetres shorter than left. Right shoulder slightly elevated. Mild prominence of left scapula. Head is tilted to left. No pain or tenderness. The original curve measures 31 degrees.



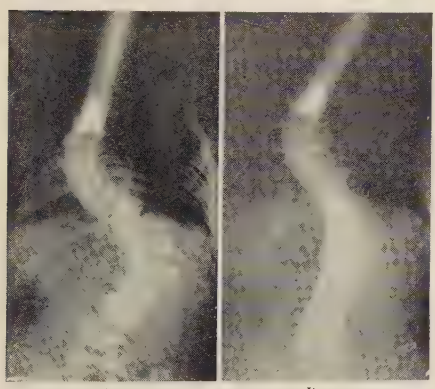
A 176068 B



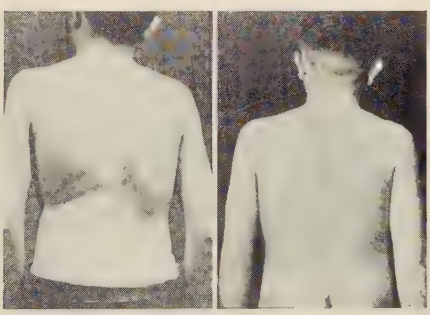
A B

C D

No. 178742 male born 5.VI.29.
Right curve D_5–D_9–D_{12}, standing 40 degrees, corrected to 20 degrees.
Spine fusion 7.IV.39 D_8–L_1
29. V.39 D_5–D_8
19.II.48. Attends school. Active in all kinds of sports. No pain, tenderness or undue fatigue. Spine looks straight. Pelvis level. Left shoulder slightly elevated. Lost 2 degrees of correction in three months. No further loss of correction.



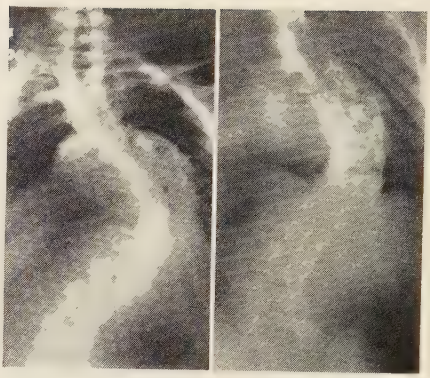
A B



C D

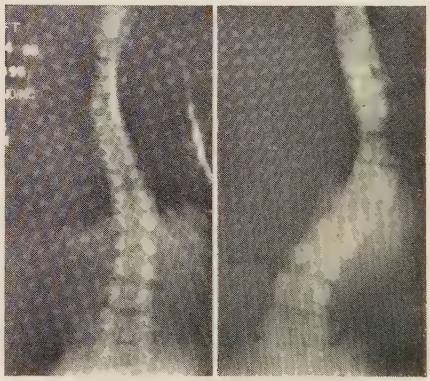
No. 179396 male born 9.VII.21.
Right curve D_9–D_{12}–L_2, standing 68 degrees, lying 57 degrees, corrected to 47 degrees.
Spine fusion 24. V.37 D_{12}–L_4
14.VI.37 D_8–D_{12}
8.IV.48. Doing clerical work full time. No pain or undue fatigue. No tenderness. There is considerable kyphosis, the lateral curvature seems to be negligible. Left shoulder slightly elevated. No hip prominence. Pelvis level. Original curve measures 58 degrees.

No. 186501 male born 31.XII.18.
Right curve D_6–D_{10}–L_1, standing 94 degrees, corrected to 56 degrees.
Spine fusion 9.XII.36 D_6–L_1
6. I.37 D_5–D_9
23.XI.48. Works eight hours a day. No pain, undue fatigue or tenderness. Severe right curve with considerable rib deformity. Left hip a little prominent. Shoulders level. Original curve 75 degrees.



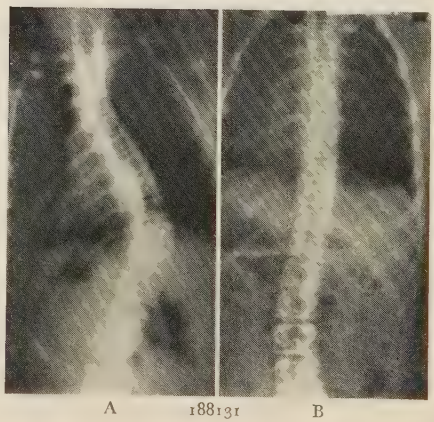
A 186501 B

No. 186819 male born 6.VII.25.
Poliomyelitis in 1935.
Left curve C_6–D_5–D_9, standing 27 degrees, corrected to 8 degrees.
Spine fusion 25. V.38 D_4–D_{10}
17.VI.38 C_6–D_4
20.IV.46. The right curve has increased, the left hip has become markedly prominent. The fusion area has maintained correction, the original curve measures 14 degrees. The lower right curve D_9–D_{12}–L_3, considered compensatory in 1938, has increased from 19 degrees to 37 degrees. Correction of the right curve and extension of fusion was advised, but refused by the patient.



A 186819 B

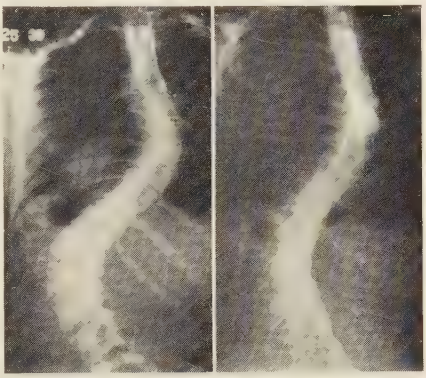
No. 188131 female born 2.II.30.
Poliomyelitis in 1935.
Right curve D_7 D_{11}-L_2, sitting 38 degrees, lying 21 degrees, corrected to 4 degrees.
Spine fusion 17. XI.41 D_{10}–L_2
8.XII.41 D_7–D_{10}
14.X.47. No pain or tenderness. Spine looks straight. No rib deformity. Walks with right long leg brace and crutches. Curve measures 8 degrees.



A 188131 B

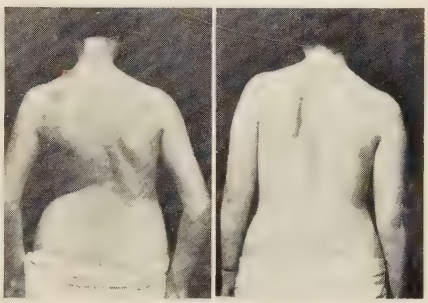
No. 189521 female born 9.VII.26.
Right curve D_6–D_9–D_{12}, standing 50 degrees, lying 34 degrees, corrected to 13 degrees.
Spine fusion 17. X.38 D_8–D_{12}
7.XI.38 D_5–D_8
16.V.44. Asymptomatic. Maintaining correction. Pelvis and shoulders level. Back looks straight. Curve measures 15 degrees.

No. 190259 female born 24.III.22.
Left curve D_{11}–L_2–L_5, standing 70 degrees, corrected to 37 degrees.
Spine fusion 31.III.39 L_2–L_5
24. IV.39 D_{10}–L_2
26.X.48. Works full time as a bookkeeper. No pain, undue fatigue or tenderness. Moderate curve, some posterior right rib deformity. Shoulders and pelvis level. No hip prominence. Lost correction to 52 degrees in nine months. No further loss. Curve measures now 54 degrees.



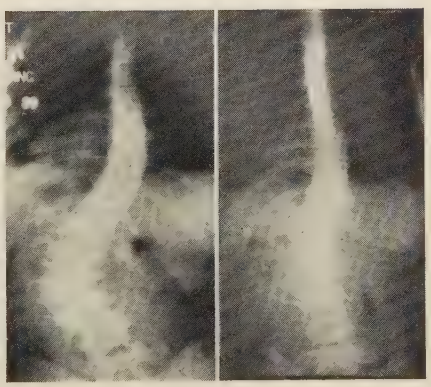
A 190259 B

No. 190297 female born 1.VIII.13.
Right curve D_9–L_1–L_4, standing 48 degrees, lying 40 degrees, corrected to 20 degrees.
Spine fusion 22. I.37 L_1–L_5
8.III.37 D_8–L_1
8.I.45. Occasional low back pain. Back appears straight. Left shoulder elevated. Pelvis level. No hip prominence. Curve measures 25 degrees.



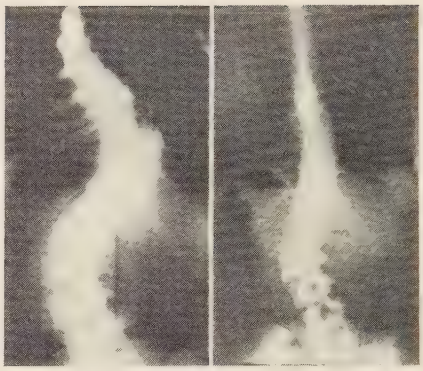
A 190297 B

No. 190907 female born 25.VII.23.
Left curve D_{11}–L_2–L_4, standing 65 degrees, corrected to 30 degrees.
Spine fusion 16.XII.38 L_2–L_4
25. I.39 D_{10}–L_2
At the second plaster change a pseudarthrosis was suspected at L_1–L_2, with no loss of correction.
2.VIII.39. Repair of pseudarthrosis.
At the level L_1–L_2 there was a well defined pseudarthrosis with slight but definite motion.
5.III.48. Working full day as a social worker. No undue fatigue or tenderness. Occasional pain in low back when standing for long time. Back looks nearly straight. Pelvis and shoulders level. Right hip slightly prominent. No rib deformity. Curve measures 32 degrees.



A 190907 B

No. 192011 female born 14.VI.24.
Right curve D_5–D_8–D_{11}, standing 59 degrees, corrected to 29 degrees.
Spine fusion 21.IV.37 D_7–D_{10}
12. V.37 D_{10}–L_1
11.VI.37 D_3–D_7
24.II.48. Working as machine operator full time. No pain, undue fatigue or tenderness. Left shoulder slightly elevated. Pelvis level. No hip prominence. No rib deformity. No loss of correction. Curve measures 30 degrees.



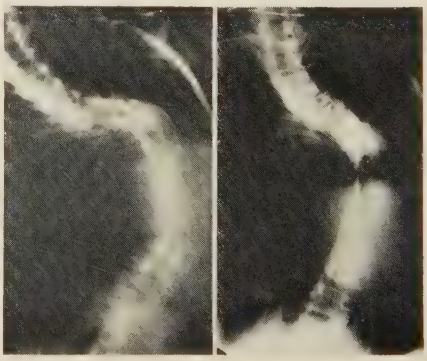
A 192011 B

No. 192208 female born 27.IV.25.
Right curve D_3–D_6–D_{12}, standing 64 degrees, lying 58 degrees, corrected to 48 degrees.
Spine fusion 29. I.37 D_3–D_6
19.II.37 C_7–D_3
The lower part of the curve had been fused elsewhere two and one half years previously.
2.XI.44. Occasional backache. Severe right curve with marked rib deformity. Right shoulder elevated. Left hip prominent. Curve measures 56 degrees.

No. 193999 female born 6.V.28.
L_4 is a hemivertebra, the right half of which has failed to develop. Left curve L_2–L_4-S_1, standing 30 degrees, lying 22 degrees. The hemivertebra was removed in two stages.
Spine fusion 8.I.37 L_2–S_1
The upper curve D_8–D_{11}–L_2 originally 27 degrees standing increased and on 19.XII.38 the fusion was extended up to D_{11}.
12.II.48. No pain, undue fatigue or tenderness. Stands with shoulders level and pelvis tilted to the right by bending the right knee. When pat. stands with both knees straight the trunk is tilted to the left and forward. Moderate posterior rib deformity and lumbar kyphosis.
Curves measure L_3–L_5–S_1 25 degrees and D_8–D_{12}–L_3 45 degrees, the upper curve having increased considerably whereas the lower is stationary. (Fig. 35 A and C).

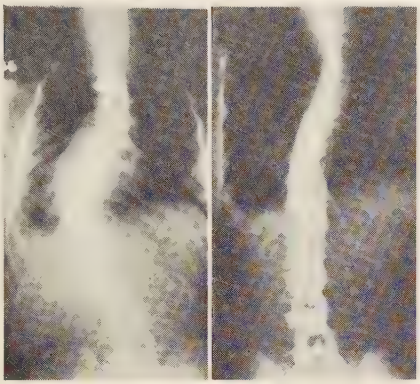
No. 194005 female born 22.II.13.
Left curve D_9–D_{12}–L_3, standing 57 degrees, corrected to 26 degrees.
Spine fusion 11. I.37 D_{10}–L_2
3.II.37 D_7–D_{10} & L_2–L_3
Pseudarthrosis was suspected after six months and 13.VIII.37 an exploration of the spine fusion was done. Fusion at the area of suspected peudarthrosis was found to be solid on both margins, with a considerable defect near the center, but no motion was present and no complete pseudarthrosis demonstrated.
29.V.44. No complaints. Mild left curve. Right shoulder elevated. Lost correction to 32 degrees in six months, no further loss. Curve measures 34 degrees.

No. 194122 female born 1.V.19.
Poliomyelitis at the age of three years involving the entire body.
Right curve D_7–L_5, standing 114 degrees, lying 62 degrees corrected to 38 degrees. This curve actually has two components, D_7–D_9–D_{12} measuring 66 degrees and D_{12}–L_2–L_5 measuring 48 degrees, both of them rather angular. On lying down, the curve straightens out to 62 degrees and the angulation disappears.
Spine fusion 30. XI.36 L_1–S_1
29.XII.36 D_9–L_1
27. I.37 D_6–D_9
3.III.42. No pain in back. Marked right curve. Trunk shifted to right. Pelvis tilted to right. Curve measures 66 degrees.



A 194122 B

No. 195384 female born 19.VIII.25.
Left curve D_7–D_{11}–L_3, standing 40 degrees, lying 21 degrees, corrected to 10 degrees.
Spine fusion 14.XII.36 D_{11}–L_3
6. I.37 D_7–D_{11}
29.VIII.45. No pain, undue fatigue or tenderness. Back looks practically straight. Pelvis and shoulders level. No hip prominence. The original curve measures 18 degrees, the upper compensatory curve is unchanged, the lower one is reversed.



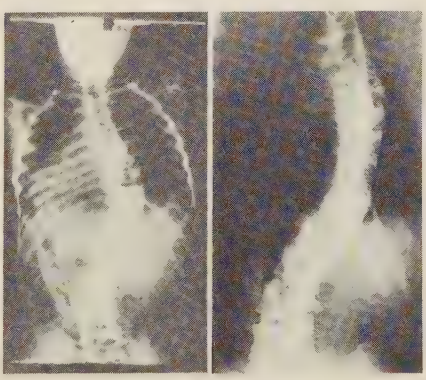
A 195384 B

No. 196717 female born 21.X.22.
Left curve D_{10}–L_1–L_4, standing 47 degrees, lying 33 degrees, corrected to 14 degrees.
Spine fusion 18.XI.36 D_{12}–L_3
15. I.37 D_9–D_{12}
14.IX.43. Complains of pain in the back for a couple of years. The muscles of the lumbar area are slightly tender. Back looks straight. Pelvis and shoulders level. Slight prominence of left hip. Curve measures 10 degrees.

No. 197352 male born 9.VII.20.
Right curve D_4–D_8–L_1, standing 42 degrees, corrected to 10 degrees.
Spine fusion 1.III.40 D_8–L_1
1.IV.40 D_3–D_8
13.IV.46. Works full time as a folding machine operator. No pain, undue fatigue or tenderness. Mild right curve. Left hip slightly prominent. Lost correction to 29 degrees in nine months. No further loss of correction.

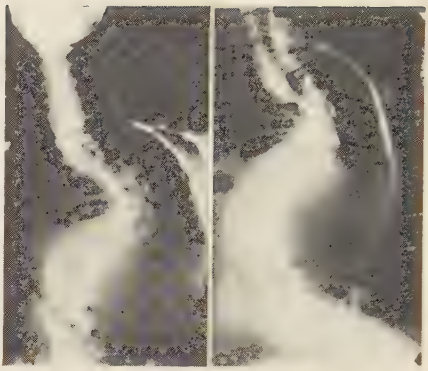
No. 197415 male born 17.III.27.
Right curve D_5–D_9–D_{12}, standing 75 degrees, corrected to 21 degrees.
Spine fusion 18. I.37 D_8–L_1
10.II.37 D_4–D_8
9.XII.43. No pain, undue fatigue or tenderness. Marked right curve with considerable rib deformity. Left shoulder slightly elevated. Right hip prominent. Lost correction to 52 degrees in six months. No further loss of correction.

No. 198416 male born 4.IV.28.
Right curve D_5–D_9–D_{12}, standing 49 degrees, lying 39 degrees, corrected to 21 degrees.
Spine fusion 15. II.37 D_8–D_{12}
8.III.37 D_4–D_8
24.II.48. Office worker. No pain, undue fatigue or tenderness. Shoulders and pelvis level some prominence of left hip. Marked right curve with considerable rib deformity and some shift of the trunk to right. The fused segment maintained correction, measures 25 degrees, but a recurrence of curve seems to be at D_{12}–L_1 and D_5–D_{12} –L_1, measures 32 degrees.



A 198416 B

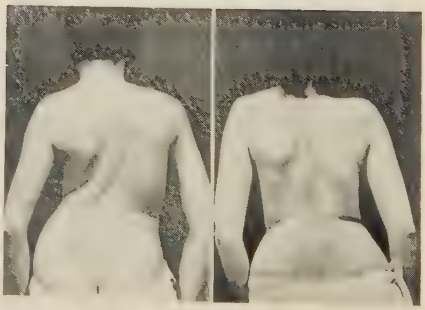
No. 198717 female born 15.XI.23.
Right curve D_6–D_9–D_{12}, standing 100 degrees, lying 89 degrees, corrected to 69 degrees.
Spine fusion 9.IV.37 D_9-L_1
3. V.37 D_4 D_9
Pseudarthrosis was suspected and 17.XI.37 an exploration of the fusion area was done between D_5 and D_{11}. It was found to be abundant, continuous, fairly mature and solid throughout the extent explored.
31.V.45. No pain or tenderness. Marked right curve and rib deformity. Shoulders level. Left hip prominent. Pelvis level. Loss of correction to 80 degrees in six months. No further loss. Curve measures 82 degrees.



A 198717 B

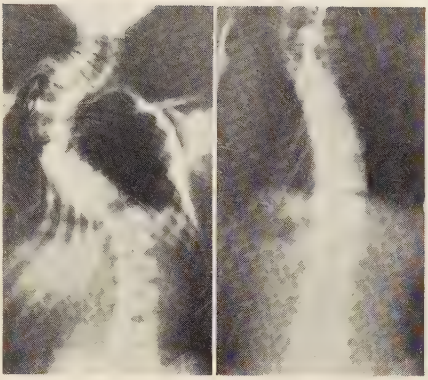
A B

No. 199742 female born 5.IX.23.
Poliomyelitis in 1927.
Right curve D_5–D_8-D_{12}, standing 54 degrees, lying 50 degrees, corrected to 31 degrees.
Spine fusion 23.IV.37 D_7 D_{12}
26. V.37 D_3 D_7
24.II.48. Working full time as a bookkeeper. No pain, undue fatigue or tenderness. Back looks straight. Slight prominence of left scapula. No trunk shift. Shoulders level. No hip prominence. Head is tilted somewhat to right. Some left pelvic tilt. Left leg two and one half centimetres short. The fused segment has maintained correction, measures 33 degrees. The upper curve, cervico-dorsal, has increased and become angular, causing the tilt of the head.



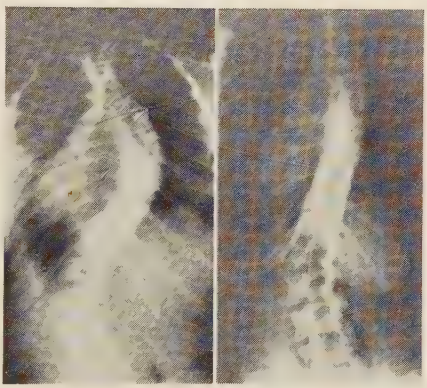
C D

No. 201444 male born 15.VII.30.
Flaccid paralysis of left foot, probably due to poliomyelitis, although there is no history of that disease.
Left curve D_2–D_6–D_{10}, standing 65 degrees, lying 50 degrees, corrected to 42 degrees.
Spine fusion 24. I.41 D_5–D_{11}
26.II.41 D_1–D_5
16.XI.48. Works eight hours a day as a radio repairman. No pain, undue fatigue or tenderness. Marked left curve with considerable rib deformity. Left shoulder elevated. Slight prominence of right hip. Curve measures 48 degrees.



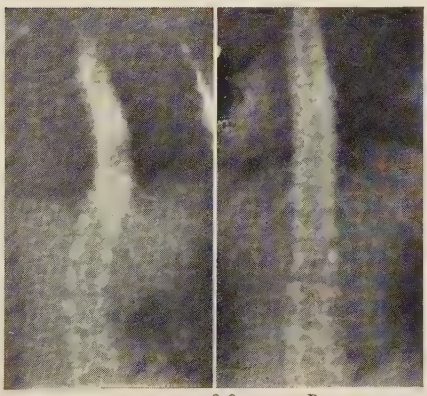
A 201444 B

No. 201747 female born 7.VIII.26.
Right curve D_4–D_8–D_{11}, standing 52 degrees, lying 46 degrees, corrected to 20 degrees.
Spine fusion 19. V.37 D_7–D_{12}
9.VI.37 D_3–D_7
16.III.48. Is married, does housework. No pain, undue fatigue or tenderness. Back looks straight. Shoulders and pelvis level. No hip prominence. Slight rib deformity. curve measures 25 degrees.



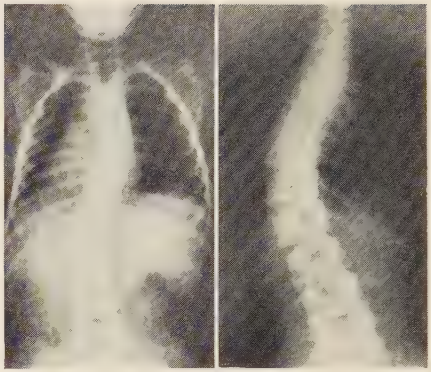
A 201747 B

No. 202648 female born 19.VI.26.
Right curve D_5–D_8–D_{12}, standing 25 degrees, corrected to 9 degrees.
Spine fusion 16.III.38 D_9–L_1
6. IV.38 D_4–D_9
25.V.48. Does clerical work. No pain or tenderness. Gets rather easily tired. Back looks straight. Slight elevation of left shoulder. No hip prominence. By an error no Roentgenogram was taken but two and one half years after operation there had been no loss of correction, the curve measuring 8 degrees.



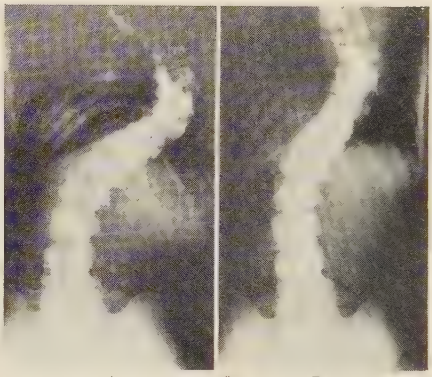
A 202648 B

No. 203311 male born 2.V.33.
Pat. born with spina bifida. Operation, type unknown, was performed at the age of one week. Pat. has bilateral talipes equino varus, two centimetres shortening of right leg.
Right curve D_3–D_6–D_9, standing 31 degrees, lying 26 degrees, corrected to 12 degrees.
Spine fusion 11. II.38 D_6–D_{10}
4.III.38 D_1–D_6
In 1943 corrective operation on both feet.
24.II.48. No pain or tenderness. Pelvis is level with six and one half centimetres lift left. Uses four centimetres left lift and walks with pelvis tilted to left, shoulders level, slight trunk shift to left. The original curve measures 17 degrees, the lower compensatory curve measures 33 degrees.



A 203311 B

No. 203783 female born 30.XI.25.
Right curve D_5–D_8–D_{11}, standing 68 degrees, lying 64 degrees, corrected to 55 degrees.
Spine fusion 18.III.42 D_8–D_{12}
8.IV.42 D_4–D_8
6.IV.48. Doing office work full time. No pain, undue fatigue or tenderness. Marked right curve with considerable rib deformity. Hips and shoulders level. Prominence of left hip. No loss of correction.

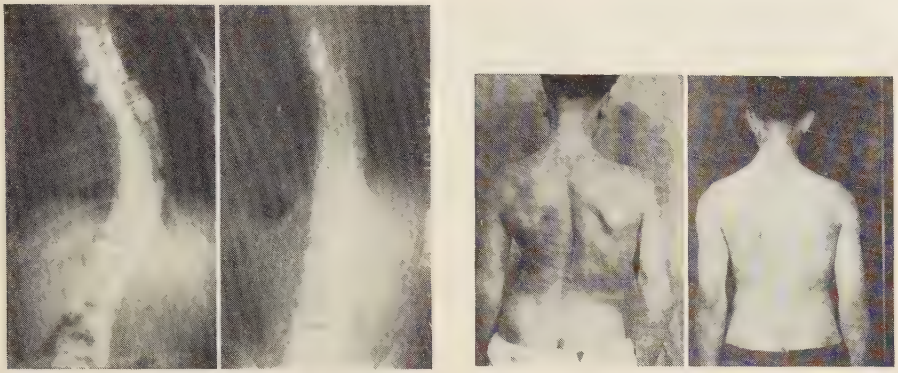


A 203783 B

No. 203796 male born 27.II.27.
Pneumonia probably followed by an empyema at the age of three years.
Right curve C_6–D_5–D_{11}, standing 50 degrees, lying 46 degrees, corrected to 40 degrees.
Spine fusion 3. XI.37 D_8–D_{12}
26. XI.37 D_3–D_8
17.XII.37 C_6–D_3
26.II.46. Severe right curve and rib deformity. Right shoulder elevated. Head tilted to left. Trunk shifted to right. Pelvis level. Left hip prominent. The original curve measures 57 degrees, however, the lower part of the fusion seems to have lost little or no correction. The main deformity now is C_6–D_2–D_7 which measures 65 degrees. (Fig. 36 A and B).

No. 205009 female born 29.X.28.
Right curve D_5–D_9–L_1, standing 43 degrees, lying 35 degrees, corrected to 15 degrees.
Spine fusion 17.XI.37 D_8–L_1
12. I.38 D_3–D_8
26.II.48. Is attending school. Participates in sports, plays tennis. Occasional low back pain. No tenderness or undue fatigue. Shoulders and pelvis level. Some prominence of left hip. Slight right curve. There has been no loss of correction in the fused area but the lower compensatory curve has reversed itself and now there is a right curve D_9–L_1–L_4 measuring 22 degrees. (Fig. 33 A and C).

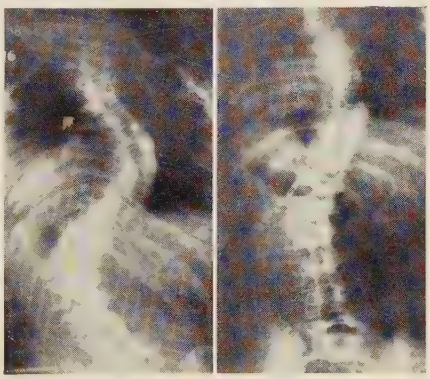
A 205009 B



A B C D

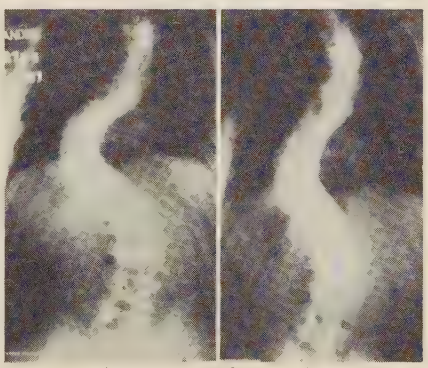
No. 205162 male born 6.V.23.
Right curve D_5–D_9–D_{12}, standing 37 degrees, lying 25 degrees, corrected to 13 degrees.
Spine fusion 5. I.38 D_9–L_1
21.II.38 D_4 D_9
18.V.48. Working as a lithographer seven hours a day, mostly standing. No pain, undue fatigue or tenderness. Slight right curve with mild rib deformity. Shoulders level. No hip prominence. Slight right pelvic tilt. Curve measures 15 degrees.

No. 205498 female born 2.II.24.
Right curve D_5–D_7–D_{10}, standing 54 degrees, lying 49 degrees, corrected to 35 degrees.
Spine fusion 8. II.39 D_8–D_{11}
8.III.39 D_3–D_8
The lower curve D_{10}–L_1–L_5, standing 72 degrees, lying 66 degrees, did not straighten out. The patient was readmitted, the curve corrected to 37 degrees.
Spine fusion 8.XI.40 D_{11}–L_2
29.XI.40 L_2–L_4
21.IX.44. No pain, undue fatigue or tenderness. Shoulders and pelvis level. Some right rib deformity. Right hip slightly prominent. The dorsal and dorso-lumbar curves measure 35 degrees and 40 degrees respectively.

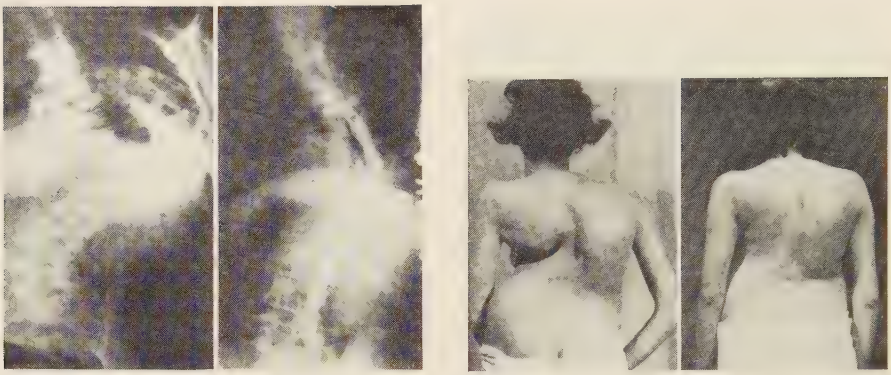


A 205498 B

No. 205716 male born 22.III.18.
Left curve D_7–D_{10}–D_{12}, standing 75 degrees, lying 64 degrees, corrected to 39 degrees.
Spine fusion 10. XI.37 D_9–L_1
10.XII.37 D_6–D_9
1.XII.42. Normal activities. No pain, undue fatigue or tenderness. Left curve with some rib deformity. Marked round back. Lost correction to 60 degrees in one year. No further loss of correction.



A 205716 B

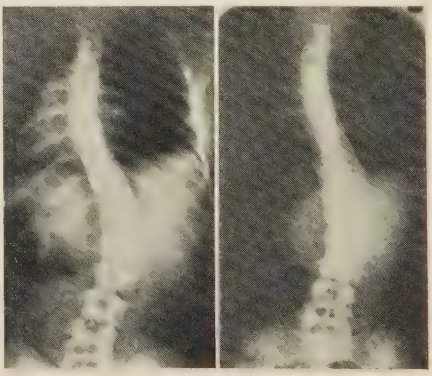


A B C D

No. 206217 female born 18.XII.18.
Right curve D_5–D_{10}–L_1, standing 101 degrees, lying 90 degrees, corrected to 68 degrees.
Spine fusion 8. I.38 D_{11}–L_3
28. I.38 D_7–D_{11}
18.II.38 D_3–D_7
27.V.48. Does clerical work. Tires easily, but has no pain. Some tenderness of the lumbar spine. Severe right curve with great posterior rib prominence. Moderate prominence of left hip. Slight right pelvic tilt and shift of trunk to right. Lost correction to 82 degrees in one year. No further loss.

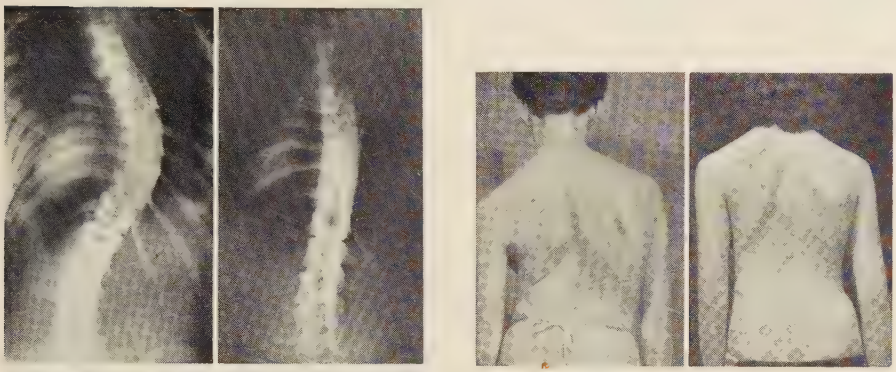
No. 206246 female born 27.XII.28.
Poliomyelitis in 1937.
Left curve D_4–D_7–D_{10}, standing 41 degrees.
Right curve D_{10}–L_1–L_3, standing 40 degrees.
Left curve corrected to 6 degrees.
Spine fusion 6.XII.39 D_7–D_{11}
3. I.40 D_4–D_7
24. I.40 D_2–D_4
The lower curve failed to straighten out. Corrected to 18 degrees.
Spine fusion 6.I.41 D_{11}–L_3
At the first plaster change pseudarthrosis was suspected at D_{11}–D_{12}.
25.IV.41. Exploration of spine fusion. Several areas showed irregular fusion, but no pseudarthrosis was detected. In January 1942 the patient fell on her back, which resulted in painful left lumbar area. She came to the clinic where examination revealed nothing. Two months later, however, it was found that she had some loss of correction and an area of possible fracture of fusion.
20.V.42. Repair of pseudarthrosis. There was a pseudarthrosis extending all the way across the fusion mass between L_1–L_2.
30.IX.48. Does clerical work. No pain, undue fatigue or tenderness. Pelvis level. No hip prominence. Left curve 19 degrees, right curve 29 degrees.

No. 206509 female born 20.V.23.
Right curve D_9–L_2–L_4, standing 42 degrees, lying 39 degrees, corrected to 8 degrees.
Spine fusion 1.XII.37 L_1–L_4
29.XII.37 D_9–L_1
Loss of correction in three months to 22 degrees.
Pseudarthrosis suspected at L_2–L_3 and D_{11}–L_1.
20.IV.38. Repair of pseudarthrosis.
Pseudarthrosis was found between D_{11}–L_1 and L_2–L_3.
The curve was recorrected to 12 degrees prior to repair operation.
24.II.48. Doing office work. No pain, undue fatigue or tenderness. Pelvis and shoulders level. Slight right curve with mild rib deformity. Left hip slightly prominent. Curve measures 30 degrees.



A 206509 B

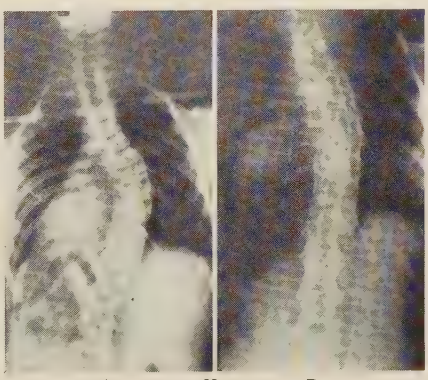
No. 206592 male born 14.V.24.
Right curve D_8–D_{12}–L_3, standing 54 degrees, corrected to 21 degrees.
Spine fusion 2.III.38 D_{11}–L_3
30.III.38 D_7 D_{11}
Loss of correction in one year to 42 degrees, pseudarthrosis suspected D_{12}–L_1.
19.V.39. Exploration of fusion. At what was thought to be the level of D_{12} a weak area was found in the fusion. No motion could be detected, but the line across the fusion was composed of immature bone. Corrected before exploration to 27 degrees.
9.IV.48. Working as a clerk. No pain, undue fatigue or tenderness. Slight right curve. Practically no rib deformity. Left shoulder elevated. Pelvis level. No hip prominence. Curve measures 30 degrees. (Fig. 34 A and E.)



A B C D

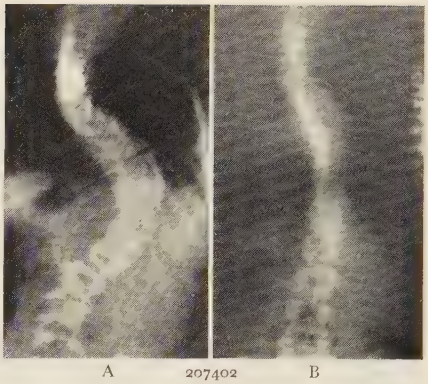
No. 206668 female born 11.XI.21.
Right curve D_4–D_8–D_{12}, standing 44 degrees, lying 35 degrees, corrected to 17 degrees.
Spine fusion 7.III.38 D_8–D_{12}
8.IV.38 D_4–D_8
8.IV.48. Works full time as a telephone operator. No pain, undue fatigue or tenderness. Mild right curve with some residual rib deformity. Pelvis and shoulders level. No hip prominence. Curve measures 20 degrees.

No. 206895 female born 21.XI.29.
Right curve D_4–D_8–L_1, standing 40 degrees, lying 37 degrees, corrected to 15 degrees.
Spine fusion 6.XII.37 D_9–L_1
27.XII.37 D_3–D_9
The fused area maintained the correction, but in 1944 L_2 and L_3 had become added to the curve which, with this addition measured 33 degrees. It was corrected to 18 degrees.
Spine fusion 20.X.44 L_1–L_3
9.I.47. No pain, undue fatigue or tenderness. Excellent balance. Shoulders level. Curve measures 24 degrees.



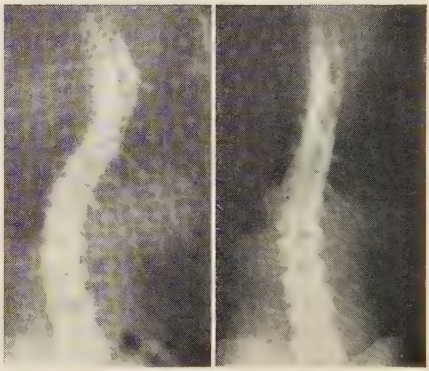
A 206895 B

No. 207402 female born 3.IV.25.
Right curve D_7–D_{11}–L_2, standing 64 degrees, lying 59 degrees, corrected to 21 degrees.
Spine fusion 17.XII.37 D_{10}–L_2
7. I.38 D_6–D_{10}
26.II.48. Has been working as a bookkeeper until recently, is going to be married. No pain, undue fatigue or tenderness. Back looks straight. Shoulders and pelvis level. No hip prominence. No rib deformity. Curve measures 28 degrees.



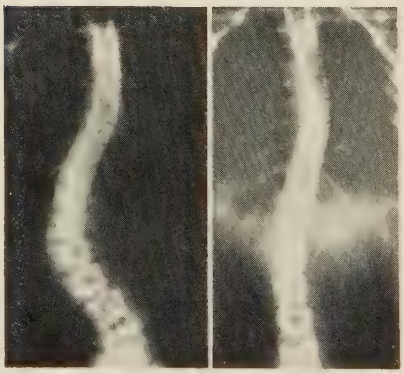
A 207402 B

No. 208096 female born 29.XII.23.
Right curve D_4–D_7–D_{10}, standing 34 degrees, corrected to 10 degrees.
Spine fusion 29.III.39 D_7–D_{11}
21. IV.39 D_3–D_7
11.III.48. Married eight months, does housework, was employed as a salesgirl before. No pain, undue fatigue or tenderness. Pelvis and shoulders level. Only slight curve noticeable. 10 degrees loss of correction in the first year. No further loss.



A 208096 B

No. 208160 female born 18.VII.23.
Right curve D_8–D_{12}–L_4, standing 40 degrees, lying 30 degrees, corrected to 10 degrees.
Spine fusion 14. I.38 D_{11}–L_3
4.II.38 D_8–D_{11}
23.XI.48. Doing office work full time. Horseback riding for recreation. No pain, undue fatigue or tenderness. Back looks straight. No rib deformity. Slight prominence of right hip. Lost correction to 16 degrees in the first year. No further loss.



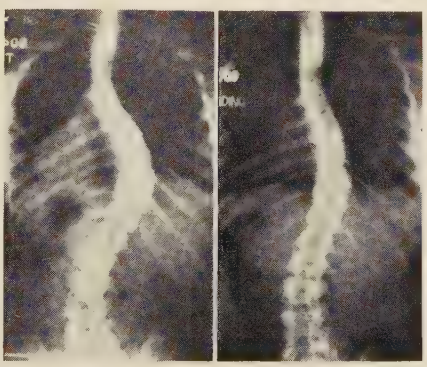
A 208160 B

A B C D

No. 210286 female born 30.XI.04.
Right curve D_6–D_{11}–L_2, standing 37 degrees, lying 27 degrees, corrected to 9 degrees.
Spine fusion 9.XII.38 D_{10}–L_2
20.XII.38 D_6–D_{10}
22.III.48. Does housework. Has noticed only a little pain in back intermittently. Slight curve with mild rib deformity. Pelvis level. Right shoulder elevated. No hip prominence. No pain or tenderness now. Roentgenogram is suggestive of pseudarthrosis between D_{11}–D_{12}. Pat. lost correction to 25 degrees in the first eighteen months. Curve measures now 29 degrees.

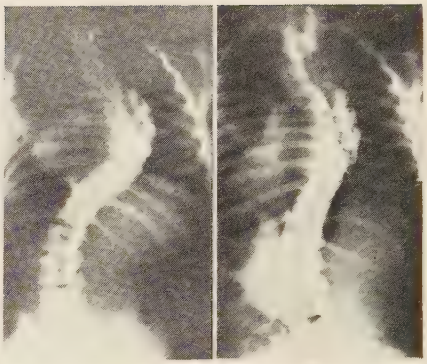
No. 210554 female born 15.IX.29.
Right curve D_4–D_9–D_{12}, standing 53 degrees, lying 45 degrees, corrected to 30 degrees.
Spina bifida L_4 and L_5. D_6–D_{11} deformed.
Spine fusion 21. XI.38 D_6–D_{12}
12.XII.38 D_3–D_6
11.V.48. Works as a receptionist. No pain, undue fatigue or tenderness. Shoulders and pelvis level. Mild right curve with some rib deformity. Left hip prominent. No loss of correction. Curve measures 30 degrees. (Fig. 38 A and B).

No. 210859 female born 19.VII.19.
Right curve D_6–D_9–L_1, standing 50 degrees, lying 42 degrees, corrected to 21 degrees.
Spine fusion 11. V.38 D_8–L_1
8.VI.38 D_5–D_8
3.VIII.43. No complaints. Excellent posture and balance. No tender areas. Pelvis and shoulders level. Curve measures 36 degrees.

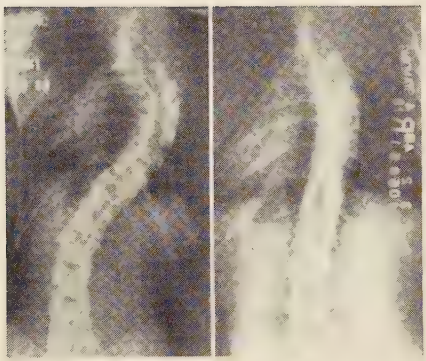


A 210859 B

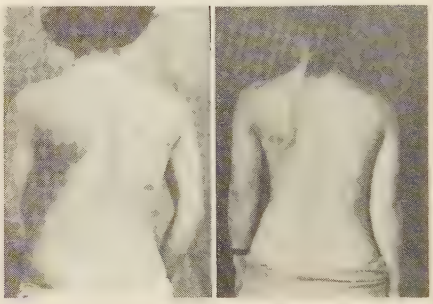
No. 211607 female born 15.I.23.
Right curve D_5–D_8–D_{11}, standing 68 degrees, lying 59 degrees, corrected to 46 degrees.
Spine fusion 5. X.38 D_9–D_{13}
24. X.38 D_6–D_9
25.XI.38 D_3–D_6
26.II.48. Does housework. No pain, undue fatigue or tenderness. Pelvis and shoulders level. Back looks straight. Some right posterior rib deformity. Cosmetically this patient is much better than could be expected from the Roentgenogram. Curve measures 50 degrees.



A 211607 B



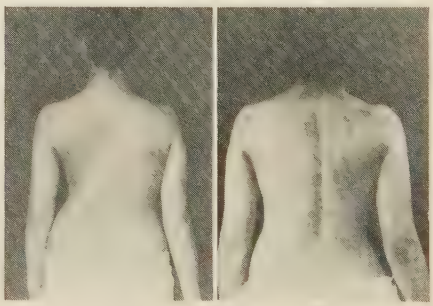
A B



C D

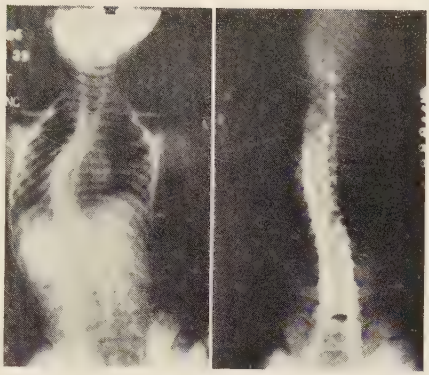
No. 211800 female born 9.VII.19.
Right curve D_5–D_8–D_{11}, standing 55 degrees, lying 45 degrees, corrected to 22 degrees.
Spine fusion 1.VI.38 D_7–D_{12}
24.VI.38 D_3–D_7
2.III.48. Married, has two children, does housework. No pain, undue fatigue or tenderness. Mild right curve with some rib deformity. Slight elevation of left shoulder and prominence of left hip. Curve measures 32 degrees.

No. 211803 female born 19.I.25.
Right curve D_5–D_9–L_1, standing 38 degrees, corrected to 13 degrees.
Spine fusion 25.III.40 D_5–D_{10}
19.IV.40 D_4–D_5 and D_{10}–L_1
2.III.48. Working as a teacher. No pain, undue fatigue or tenderness. Back looks straight. Left shoulder slightly elevated. No hip prominence or rib deformity. Lost correction to 20 degrees in nine months. Curve measures 24 degrees 11.XII.47.

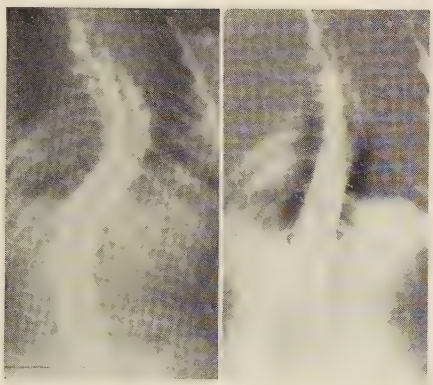


A 211803 B

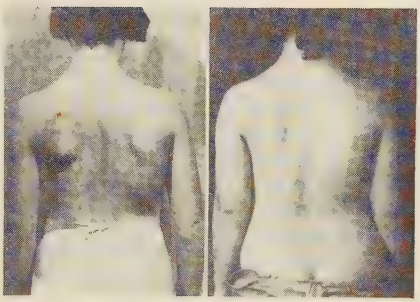
No. 211858 male born 22.VII.35.
Left curve D_5–D_{10}–L_2, standing 49 degrees, corrected to 4 degrees.
Spine fusion 20.XI.39 D_9–L_2
17. I.40 D_4–D_9
26.II.48. No pain, undue fatigue or tenderness. Back looks straight. No hip prominence or rib deformity. Curve measures 14 degrees.



A 211858 B



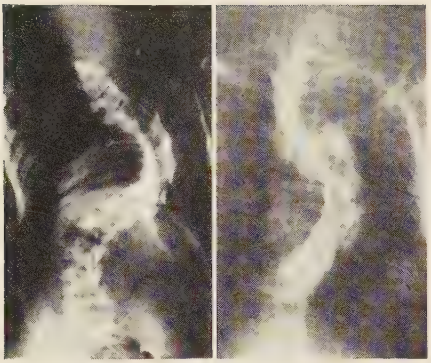
A B



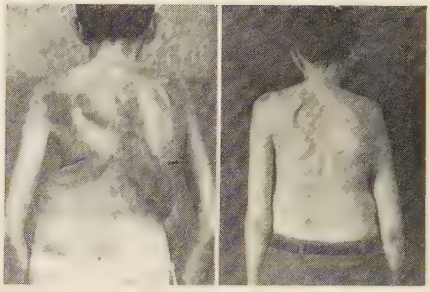
C D

No. 212199 female born 18.II.26.
Right curve D_5–D_8–D_{11}, standing 48 degrees, lying 40 degrees, corrected to 20 degrees.
Spine fusion 18. XI.38 D_8–D_{12}
14.XII.38 D_4–D_8
25.II.48. Working as a seemstress. No pain, undue fatigue or tenderness. Pelvis and shoulders level. Slight right curve with mild right rib deformity. Loss of correction in six months to 32 degrees. No further loss. Curve measures 32 degrees (16.X.47).

No. 212409 female born 3.III.20.
Right curve D_{11}–L_2–L_4, standing 91 degrees, lying 75 degrees, corrected to 45 degrees.
Spine fusion 27.X.41 D_{11}–L_3
At the first plaster change the patient had lost correction to 55 degrees. Pseudarthrosis was suspected at L_1–L_2–L_3.
25.II.42. Repair of pseudarthrosis.
There was a pseudarthrosis between L_2–L_3. Joint cartilage was present here. Very fine pseudarthrosis between D_{12}–L_1. No correction was attempted prior to the repair operation.
26.II.48. Works as a secretary and does housework. Recently some low back pain. No undue fatigue or tenderness. Pelvis tilted slightly to the left. Shoulders level. Left hip prominent. There is a marked kyphosis present which overshadows the lateral curvature. The patient is especially pleased with the absence of pain, which was severe prior to the operation. Curve measures 75 degrees.



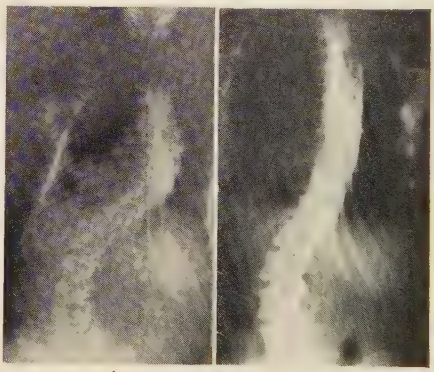
A B



C D

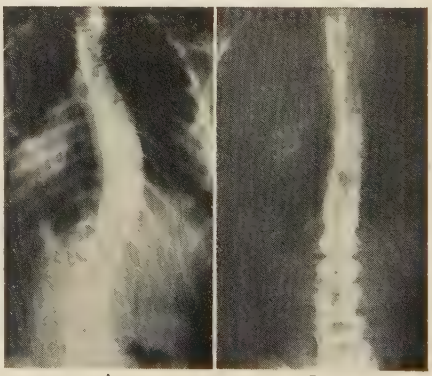
No. 212697 male born 25.V.27.
Right curve D_5–D_9–L_1, standing 93 degrees, lying 80 degrees, corrected to 55 degrees.
Spine fusion 12. X.38 D_{10}–L_2
14. XI.38 D_6–D_{10}
7.XII.38 D_3–D_6
26.II.48. Attends college. Participates in light sports. No pain, undue fatigue or tenderness. Pelvis level. Right hip prominent. Left shoulder elevated, head tilted to the right. Back looks fairly straight, but there is some right posterior rib deformity. Lost correction to 66 degrees in the first year. Curve measures now 69 degrees.

No. 213407 female born 23.XI.31.
Poliomyelitis in 1935.
Right curve D_3–D_7–D_{10}, standing 40 degrees, lying 33 degrees, corrected to 19 degrees.
Spine fusion 28. XI.38 D_7–D_{11}
19.XII.38 D_2–D_7
2.III.48. Normal activities. No pain, undue fatigue or tenderness. Mild right curve with moderate rib deformity and some prominence of left hip. Slight pelvic tilt to the left. Curve measures 22 degrees.



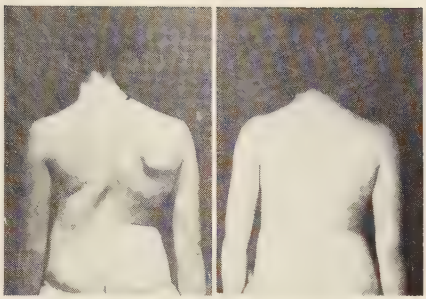
A 213407 B

No. 215050 female born 23.V.25.
Right curve D_5–D_9–L_1, standing 33 degrees, lying 26 degrees, corrected to 8 degrees.
Spine fusion 14. X.38 D_9–L_1
4.XI.38 D_5–D_9
16.XI.48. Works at dressmaking eight hours a day. No pain, undue fatigue or tenderness. Back looks straight. Pelvis and shoulders level. Slight prominence of right hip and right rib deformity. Loss of correction to 13 degrees in nine months. No further loss of correction.



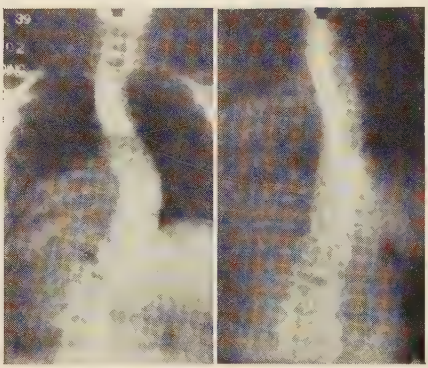
A 215050 B

No. 215154 female born 10.X.21.
Right curve D_5–D_8–D_{12}, standing 45 degrees, lying 38 degrees, corrected to 21 degrees.
Spine fusion 20.III.39 D_8–L_1
10.IV.39 D_4–D_8
1. V.39 L_5–S_1
The lumbo-sacral fusion was done for sacralisation of the lowest lumbar vertebra.
2.III.48. Is married, pregnant in 6th month, has an eighteen months old baby. Has been working as a bookkeeper and doing housework. No pain, undue fatigue or tenderness. Some right curve with mild right rib deformity. Shoulders and pelvis level. Right hip prominence. Pat. lost correction to 32 degrees.



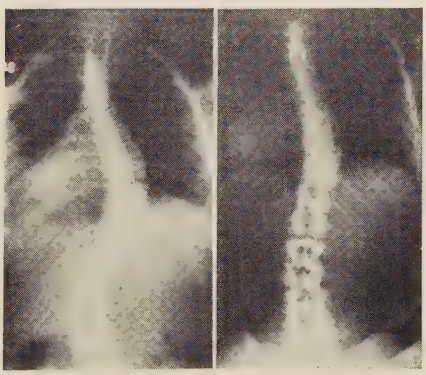
A 215154 B

No. 215624 male born 21.XII.28.
Right curve D_6–D_{10}–L_2, standing 45 degrees, lying 37 degrees, corrected to 16 degrees.
Spine fusion 26. II.40 D_{10}–L_2
20.III.40 D_5–D_{10}
2.III.48. Attending college. No pain, undue fatigue or tenderness. Slight right curve with moderate rib deformity. Shoulders level. Slight left pelvic tilt. No hip prominence. Curve measures 26 degrees.



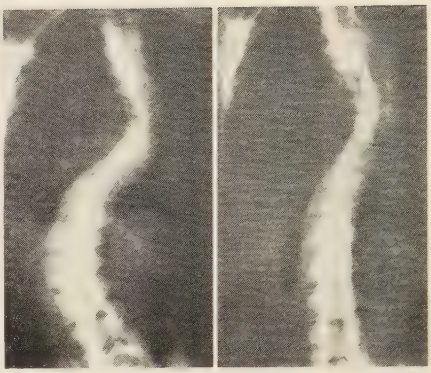
A 215624 B

No. 216084 female born 26.VI.25.
Right curve D_6–D_9–D_{12}, standing 48 degrees, corrected to 19 degrees.
Spine fusion 3.XI.39 D_9–L_1
23.XI.39 D_5–D_9
16.III.48. Is married. Does housework. No pain, undue fatigue or tenderness. Back looks straight. Pelvis and shoulders level. No hip prominence. No rib deformity. Loss of correction to 24 degrees in six months. 20.V.43 curve measured 27 degrees.



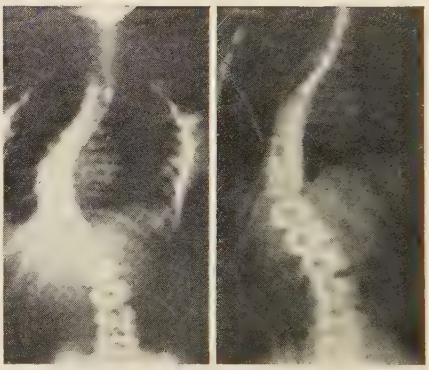
A 216084 B

No. 216202 male born 6.VII.22.
Left curve D_9–L_1–L_4, standing 57 degrees, corrected to 25 degrees.
Spine fusion 9.III.42 D_9–L_1
30.III.42 L_1–L_4
16.XI.48. Does office work seven hours a day. No pain, undue fatigue or tenderness. Rather marked right dorsal curve with considerable kyphosis. Pelvis and shoulders level. No hip prominence. There has been no loss of correction. 7.II.47 the curve measured 27 degrees.



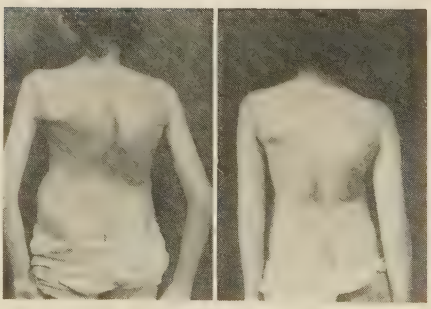
A 216202 B

No. 217027 male born 29.IX.30.
Left curve D_4–D_8–D_{12}, standing 53 degrees, lying 48 degrees, corrected to 28 degrees.
Spine fusion 8.XI.40 D_8–D_{12}
29.XI.40 D_4–D_8
12.IX.46. Mild left curve with some rib deformity. Right shoulder elevated. Curve measures 38 degrees. L_1 and L_2 are added to the upper curve.



A 217027 B

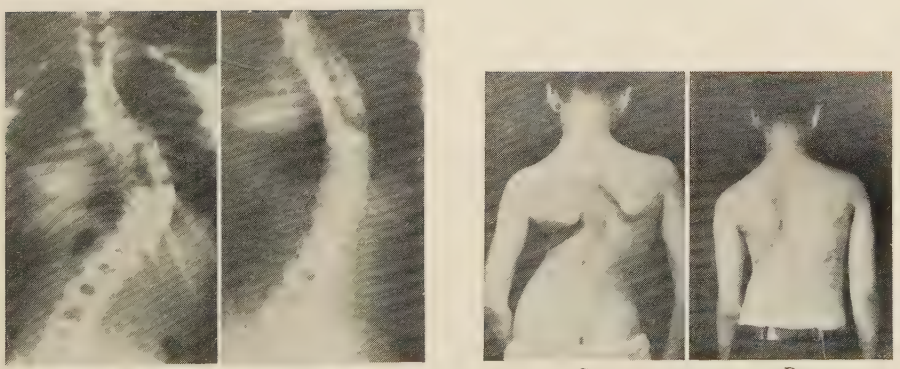
No. 218305 female born 6.IX.25.
Right curve D_8–D_{10}–D_{12}, standing 92 degrees, corrected to 50 degrees.
Spine fusion 13. I.39 D_9–L_2
6.III.39 D_5–D_9
11.III.48. Doing office work and active in sports. No pain, undue fatigue or tenderness. Severe kyphosis, that conceals the lateral curve to a great extent. Pelvis and shoulders level. No hip prominence. Loss of correction to 60 degrees.



A 218305 B

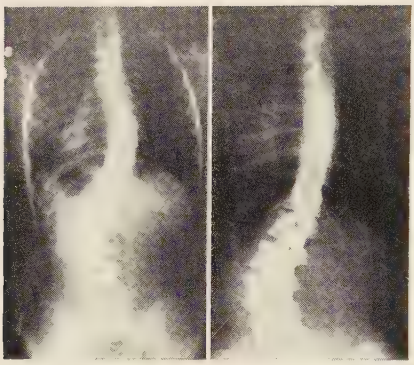
A B C D

No. 218589 male born 17.VII.22.
Right curve D_5–D_8–D_{11}, standing 45 degrees, corrected to 14 degrees.
Spine fusion 16. I.39 D_8–D_{12}
8.II.39 D_4–D_8
22.III.48. Cab driver. No pain, undue fatigue or tenderness. Back looks straight. Slight elevation of right shoulder and prominence of right hip. Mild rib deformity. Curve measures 25 degrees.

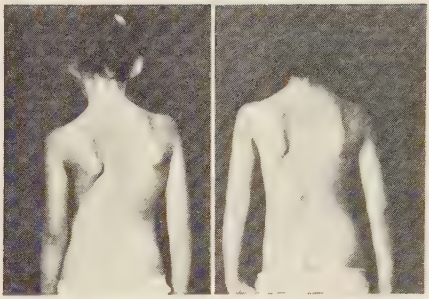


A B C D

No. 219009 male born 7.VIII.26.
Right curve D_5–D_{10}–L_2, standing 60 degrees, lying 48 degrees, corrected to 20 degrees.
Spine fusion 16. I.39 D_{10}–L_2
10.III.39 D_5–D_{10}
Loss of correction in nine months to 30 degrees.
8.III.40. Repair of pseudarthrosis.
A pseudarthrosis was found at D_9–D_{10} moving freely with respiration. Curve was corrected to 24 degrees prior to repair operation.
2.III.48. Attending academic course. No pain, undue fatigue or tenderness. Marked right curve. Shoulders level. Pelvis tilted to the right. Trunk shifted to the right. Has four centimetres shortening of right leg. Curve measures 38 degrees.



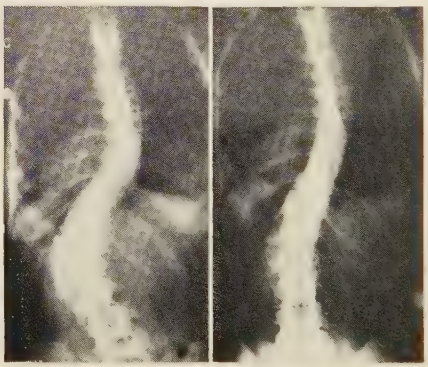
A B



C D

No. 219264 female born 2.VI.30.
Right curve D_5–D_8–D_{11}, standing 37 degrees, corrected to 6 degrees.
Spine fusion 6.XII.39 D_8 D_{12}
29.XII.39 D_4–D_8
2.III.48. No pain, undue fatigue or tenderness. Mild right curve, no rib deformity. Pelvis and shoulders level. Slight prominence of right hip. The lower curve has increased nearly 10 degrees. The original curve measures 15 degrees.

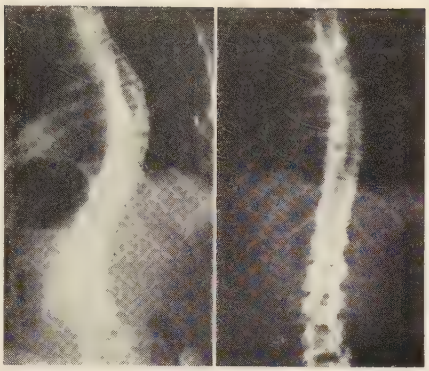
No. 219751 female born 8.V.23.
Left curve D_{10}–L_1–L_4, standing 58 degrees, lying 58 degrees, corrected to 27 degrees.
Spine fusion 2.VI.39 D_9–L_1
23.VI.39 L_1–L_4
24.III.48. Works as cosmetic inspector. Occasional pain in low back. No undue fatigue or tenderness. Back looks practically straight. Slight rib deformity. Pelvis level. Right shoulder slightly elevated. Curve measures 33 degrees.



A 219751 B

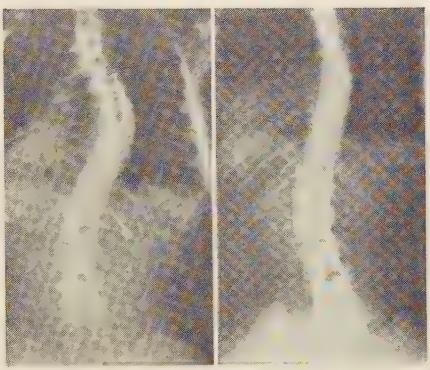
No. 219793 female born 10.VI.03.
Left curve D_8–D_{12}–L_3, standing 115 degrees, lying 102 degrees. No correction attempted.
Spine fusion 20.V.40 D_6–D_{11}
Solid natural fusion was found D_{11}–L_2.
Six months later pseudarthrosis was suspected between D_{10}–D_{11}.
2.XII.40. Repair of pseudarthrosis.
Spine fusion L_2–L_3
An irregular pseudarthrosis was found at D_9–D_{10}.
24.X.46. Patient is having pain in back, which is chiefly radiating in nature. No tenderness. Severe left curve with marked rotation. Trunk is shortened and costal margins are close to iliac crests. Pelvis and shoulders level. The patient is very nervous. Lost two sons in war. Curve measures 103 degrees.
Following the pseudarthrosis repair the fusion was to be extended to the sacrum because of persisting pain in the back and it was to seek relief of pain that she came to the clinic. But following a transfusion preparatory to the second stage operation, the patient had a severe reaction with anuria. She improved following conservative treatment but it was decided to do no further surgery at that time. She was to return in two weeks, but has not reported.

No. 219809 female born 29.VII.25.
Right curve D_5–D_8–D_{12}, standing 43 degrees, corrected to 12 degrees.
Spine fusion 29. XI.39 D_8–L_1
27.XII.39 D_4–D_8
The patient remained well corrected and asymptomatic until January 1942 when she developed aching and pain in mid-fusion area. X-rays showed the fusion weak at D_8–D_{10} but no definite break in continuity could be seen.
12.II.44. Exploration of fusion area.
No pseudarthrosis could be found, but in the midportion of the fusion plate, in the region of greatest tenderness, a bony ridge resembling a spinous process jutted outward. This prominence was levelled with an osteotom. No other cause of her discomfort could be found.
26.XII.44. Still has very slight tenderness over the operation area. Back looks practically straight. Curve measures 22 degrees.



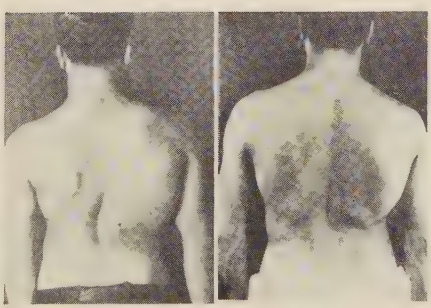
A 219809 B

No. 220164 female born 6.III.25.
Right curve D_5–D_8–D_{11}, standing 40 degrees, lying 35 degrees, corrected to 12 degrees.
Spine fusion 10. V.39 D_7–D_{11}
5.VI.39 D_4-D_7
20.X.45. Working as a receptionist full time. No pain, undue fatigue or tenderness. Shoulders level. No rib deformity. Loss of correction in nine months to 25 degrees. No further loss.

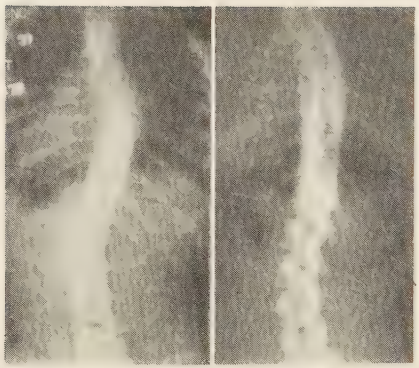


A 220164 B

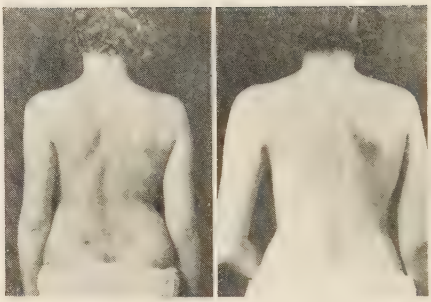
No. 220521 male born 30.VII.19.
Right curve D_4–D_8 D_{11}, standing 58 degrees, lying 51 degrees, corrected to 34 degrees.
Spine fusion 20. XI.39 D_7–D_{12}
29.XII.39 D_3–D_7
19.III.48. Occasional back pain. Moderate curve with considerable rib deformity. No tenderness. Pelvis and shoulders level. Lost correction to 40 degrees.



A 220521 B



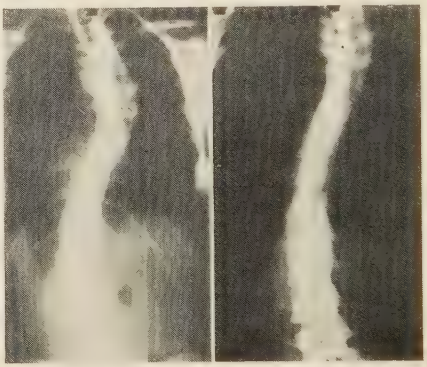
A B



C D

No. 220642 female born 22.XII.28.
Spine fusion 16. X.39 D_7–D_{11}
6.XI.39 D_3–D_7
Right curve D_4–D_7–D_{11}, standing 36 degrees, lying 23 degrees, corrected to 17 degrees.
2.III.48. Does secretarial work full time. No pain, undue fatigue or tenderness. Back looks straight. Pelvis and shoulders level. No hip prominence. Curve measures 27 degrees.

No. 220728 female born 8.III.27.
Right curve D_3–D_6–D_9, standing 41 degrees, lying 37 degrees. Left curve D_9–D_{12}–L_3, standing 27 degrees, lying 17 degrees. Right curve corrected to 28 degrees.
Spine fusion 9. VI.39 D_7–D_9
5.VII.39 D_4–D_7 and D_9–D_{10}
11. IX.39 D_1–D_4
In July 1940 a pseudarthrosis was suspected at D_4–D_5.
4.X.40. Repair of pseudarthrosis.
There was a definite pseudarthrosis at a level estimated D_4–D_5. The rest of the fusion area was solid. The patient remained poorly balanced with list of the trunk to left and prominent right hip. Left curve corrected to 17 degrees.
Spine fusion 28.V.41 D_{10}–L_3.
At the second plaster change a pseudarthrosis was suspected at D_{10}–D_{11}, D_{11}–D_{12} and D_{12}–L_1.
23.III.42. Repair of pseudarthrosis.
There was a narrow irregular pseudarthrosis at D_{10}–D_{11} bridged by firm fibrous tissue.
28.II.46. Pat. is working. No pain or tenderness. Prominence of right hip. Good posture and balance. Right curve 30 degrees, left curve 19 degrees.



A 220728 B

No. 220961 female born 24.I.24.
Right curve D_5–D_9–L_1, standing 38 degrees, lying 33 degrees, corrected to 13 degrees.
Spine fusion 6.XII.40 D_8–L_1
27.XII.40 D_4–D_8
2.III.48. Married, has one child. No pain, undue fatigue or tenderness. Back looks straight. Pelvis and shoulders level. No rib deformity or hip prominence. Lost correction to 18 degrees in six months. No further loss.

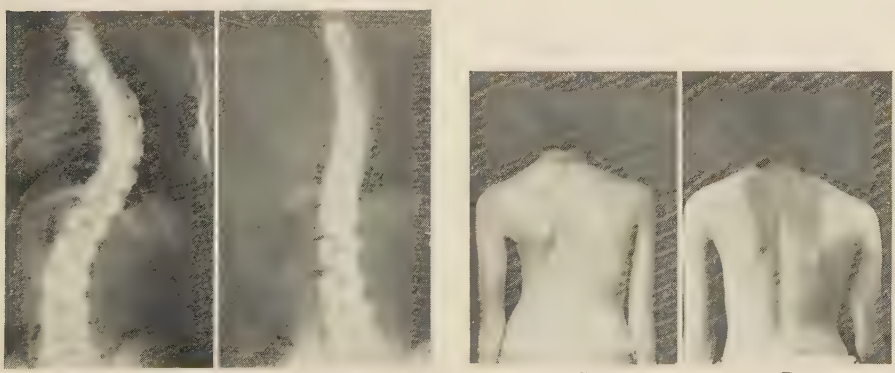
No. 222306 female born 10.XII.23.
Right curve D_4–D_7–D_{10}, standing 44 degrees, lying 41 degrees, corrected to 24 degrees.
Spine fusion 29. V.39 D_3–D_7
21.VI.39 D_7–D_{11}
9.III.48. Has had low back pain since shortly after she was discharged. X-ray showed asymmetrical articulations L_5–S_1. 16.I.48 fusion of L_5–S_1. Allowed up three weeks later. Back looks straight. Shoulders and pelvis level. Right hip slightly prominent. Curve measures 24 degrees.

No. 222408 male born 18.II.33.
At the age of one year pat. developed right pneumonia, which developed into an empyema and since then he has undergone numerous surgical procedures for drainage of the empyema cavity, six ribs having been resected at various times and hospitals. About two years ago mother noticed that the pat.'s back was curved and the curvature has increased under observation in the clinic during the last year.
Right curve D_5–D_8–D_{12}, standing 36 degrees, lying 31 degrees, corrected to 18 degrees.
Spine fusion 30.IV.41 D_8–D_{12}
23. V.41 D_4–D_8
15.I.48. No pain, undue fatigue or tenderness. Pelvis and shoulders level. Mild rib deformity. Slight prominence of right hip. Curve measures 20 degrees. (Fig. 37 A and B).

No. 222829 female born 15.VI.08.
Right curve D_7–D_{10}–D_{12}, standing 105 degrees, lying 95 degrees, corrected to 91 degrees.
Since the age of fifteen years the pat. has worn a brace because of pain and fatigue after being on her feet any length of time. Pain is located in lower dorsal region.
Spine fusion 27. XI.39 D_7–L_2
18.XII.39 D_5–D_7
19.IV.48. Does housework. No pain in back. No undue fatigue. No tenderness. Pelvis and shoulders level. Severe right curve with very big rib deformity. Curve measures 95 degrees.

A B C D

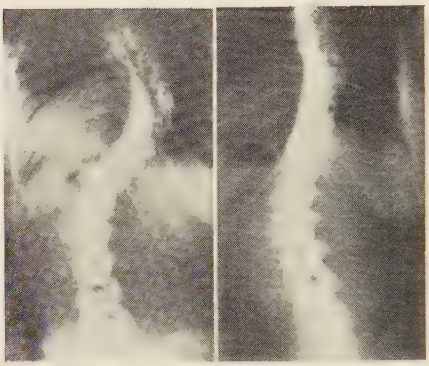
No. 223127 female born 12.IV.28.
Right curve D_5–D_8–D_{11}, standing 29 degrees, corrected to 10 degrees.
Spine fusion 17.I.40 D_5–D_{11}
5.III.48. Is married, does housework. No pain. Occasional fatigue. No tenderness. Back looks straight. Pelvis and shoulders level. No rib deformity or hip prominence. Curve measures 10 degrees.



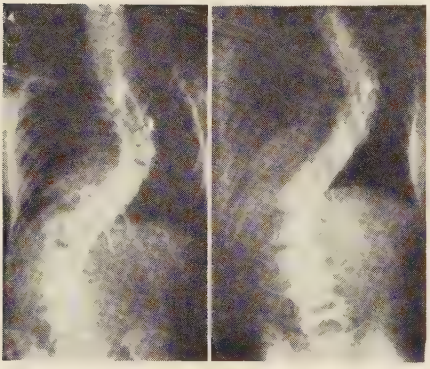
A B C D

No. 223162 female born 13.II.25.
Right curve D_6–D_9–D_{12}, standing 43 degrees, lying 41 degrees, corrected to 21 degrees.
Spine fusion 23. II.40 D_9–L_1
22.III.40 D_5–D_9
5.III.48. Pat. has been in State Hospital for six months in two periods for "extreme nervousness". She is doing no work, is still somewhat depressed, is afraid the spine will crack. She has no pain. Back looks straight. Mild rib deformity. Left shoulder slightly elevated. Pelvis level. Pat. is afraid to move the back, but with some persuasion she bends forwards so that the fingers reach the floor, knees straight. No tenderness. Curve measures 28 degrees.

No. 223641 female born 3.IX.24.
Right curve D_5–D_8–D_{11}, standing 53 degrees, lying 53 degrees, corrected to 30 degrees.
Spine fusion 13.XII.39 D_7–D_{11}
10. I.40 D_4–D_7
11.III.48. Married. Works full time as a typist and does some additional housework. No pain, undue fatigue or tenderness. Mild right curve with moderate rib deformity. Shoulders and pelvis level. No loss of correction (31 degrees).



A 223641 B

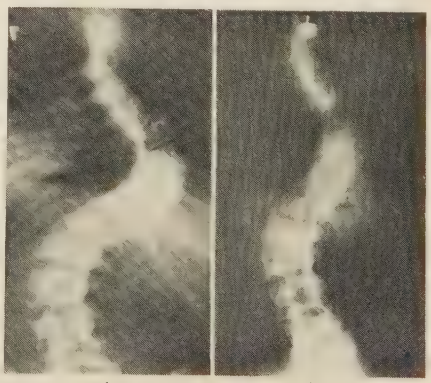


A B

C D

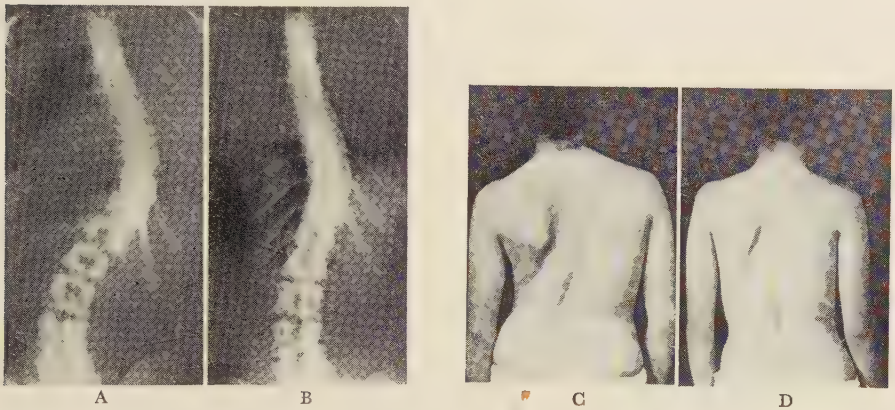
No. 225383 female born 24.VI.27.
Right curve D_4–D_7–D_{11}, standing 58 degrees, lying 52 degrees, corrected to 30 degrees.
Spine fusion 25. X.39 D_7–D_{12}
15.XI.39 D_3–D_7
At the second plaster change the pat. had lost 15 degrees of correction, most of the loss occurring a D_8–D_9.
Recorrected to 38 degrees.
3.VI.40. Exploration of fusion.
At the level of D_8–D_9 was found an irregular line, running across the fusion mass, composed of bone distinctly softer than that of the fusion mass above and below it. The area of softened bone did not include the lateral articulations on either side. No motion was elicited even after all of the soft bone had been removed with a curette.
5.III.48. Working as a stenographer. No pain, undue fatigue or tenderness. Moderate right curve with considerable rib deformity. Pelvis and shoulders level. Right hip prominent. Curve measures 51 degrees.

No. 225773 female born 3.VIII.25.
Right curve D_6–D_8–D_{11}, standing 73 degrees, lying 66 degrees, corrected to 37 degrees.
Spine fusion 15. I.40 D_8–D_{12}
9.II.40 D_4–D_8
5.III.48. Working eight hours a day. No pain or tenderness. Occasional fatigue. Back would look pretty straight but for the curved scar. Shoulders and pelvis level. Mild rib deformity. No hip prominence. The patient is rather obese and that diminishes the deformity to some extent. Loss of correction to 57 degrees.



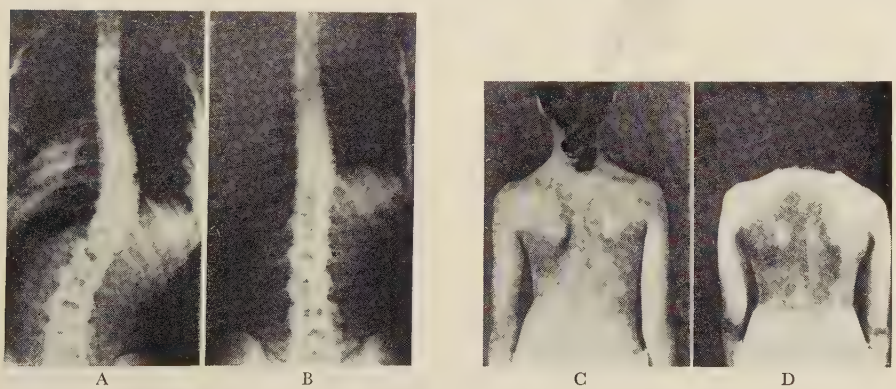
A 225773 B

No. 225987 female born 15.VII.27.
Right curve D_3–D_8–L_1, standing 55 degrees, lying 48 degrees, corrected to 14 degrees.
Spine fusion 17. XI.39 D_9–L_1
8.XII.39 D_5–D_9
3. I.40 D_2–D_5
Gradual loss of correction to 48 degrees in one year.
Pseudarthrosis suspected between D_8–D_9.
11.IV.41. Repair of pseudarthrosis.
A one millimetre defect in the firm bony mass was seen at D_8 and definite motion with respiration was demonstrated. Corrected to 30 degrees prior to repair operation.
5.III.48. Is married and has one child. Works as a secretary seven hours a day. No pain, undue fatigue or tenderness. Pelvis and shoulders level. Slight right curve. Moderate right rib deformity. Loss of correction to 40 degrees in nine months following repair operation. Curve measures now 40 degrees. (Fig. 29 A and E).



A B C D

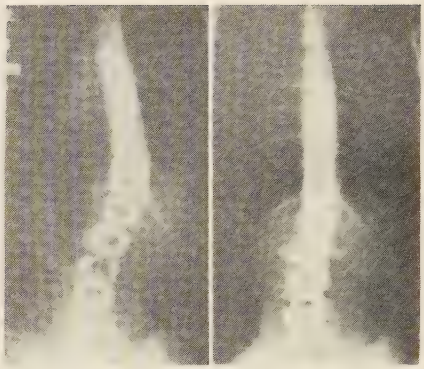
No. 226599 female born 22.X.22.
Right curve D_5–D_9–D_{12}, standing 42 degrees, lying 38 degrees, corrected to 17 degrees.
Spine fusion 20. XI.39 D_5–D_8
11.XII.39 D_8–L_1
15.VIII.48. Married. Does secretarial work. No pain, undue fatigue or tenderness. Back looks straight. Pelvis and shoulders level. No rib deformity. No hip prominence. Curve measures 22 degrees.



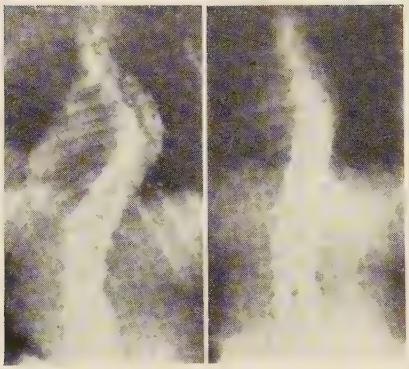
A B C D

No. 227274 female born 23.XII.25.
Right curve D_7–D_{10}–L_1, standing 31 degrees, corrected to 10 degrees.
Spine fusion 21. X.40 D_8–D_{12}
11.XI.40 D_5–D_8 & D_{12}–L_1
11.III.48. Working full time as a stenographer. No pain, undue fatigue or tenderness. Back straight. Shoulders and pelvis level. No rib deformity. No hip prominence. Loss of correction to 13 degrees.

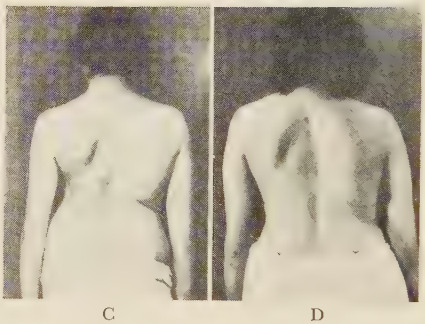
No. 228078 female born 21.X.24.
Right curve D_8-D_{12}–L_2, standing 24 degrees, lying 20 degrees, corrected to 0 degrees.
Spine fusion 22.I.40 D_8–L_2
19.III.48. Works as a secretary. No pain, undue fatigue or tenderness. Pelvis and shoulders level. No rib deformity. Slight prominence of right hip. Curve measures 10 degrees.



A 228078 B



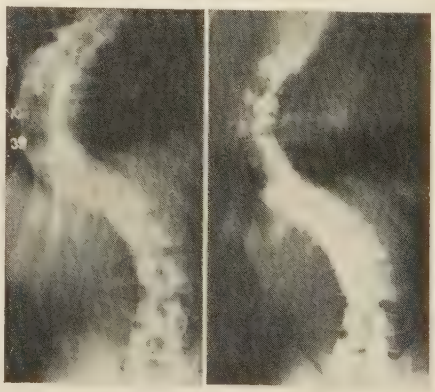
A B



C D

No. 228115 female born 11.IV.26.
Right curve D_5-D_8–D_{11}, standing 60 degrees, lying 52 degrees, corrected to 38 degrees.
Spine fusion 1.IV.40 D_7–D_{12}
22.IV.40 D_4–D_7
9.III.48. Married. Has a three year old baby. Does housework. No pain or tenderness. Occasional fatigue. Mild right curve with some rib deformity. No hip prominence. Left shoulder elevated. Curve measures 35 degrees.

No. 229492 male born 29.III.17.
Left curve D_5–D_8–D_{12}, standing 77 degrees, lying 76 degrees, corrected to 54 degrees.
19.III.41. Exploration of spine for contemplated fusion D_8–L_1. All articulations which were exposed at this operation with the exception of the articulation on the left side between D_9–D_{10} were found to be fused. No motion was present at any of the joints.
Spine fusion 16.V.41 D_4–D_8
4.III.47. Occasional low back pain for about one year. No symptoms referable to fusion area. Loss of correction to 68 degrees in three months. No further loss.

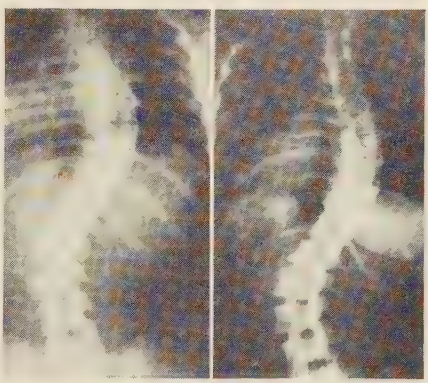


A 229492 B

No. 230388 female born 30.IX.27.
Right curve D_5–D_8–D_{12}, standing 38 degrees, lying 22 degrees, corrected to 11 degrees.
Spine fusion 8.V.40 D_8–D_{12}
29.V.40 D_4–D_8
11.XII.47. Normal activities. No pain, undue fatigue or tenderness. Mild right rib deformity and slight prominence of left hip. Pelvis and shoulders level. Curve measures 19 degrees.

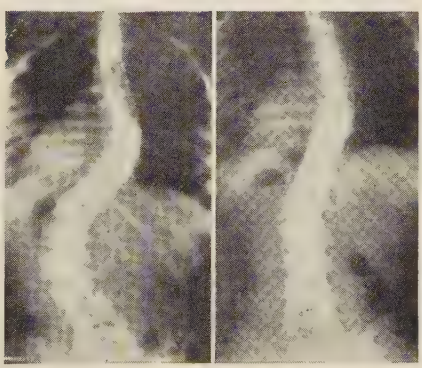
No. 230436 female born 26.III.21.
Right curve D_5–D_9–L_1, standing 55 degrees, lying 48 degrees, corrected to 19 degrees.
Spine fusion 22.IV.40 D_9–L_1
13. V.40 D_4–D_9
Loss of correction to 38 degrees in one year. At that time a pseudarthrosis at D_{10}–D_{11} was suspected.
In March 1945 the patient returned with pain and tenderness at the apex of the curve.
29.VI.45. Repair of pseudarthrosis.
A complete pseudarthrosis existed at D_{11}–D_{12} such that the fused areas distal and proximal were completely independent of one another.
25.V.48. Works as a bookkeeper. No pain or tenderness. Tires rather easily. Shoulders and pelvis level. Marked right curve, severe right rib deformity, some prominence of left hip. Trunk slightly shifted to the right. Curve measures 38 degrees. (Fig. 30 A and D).

No. 231183 female born 9.XI.21.
Right curve D_5–D_8–D_{11}, standing 46 degrees, lying 40 degrees, corrected to 33 degrees.
Spine fusion 25. XI.40 D_8–D_{12}
18.XII.40 D_4–D_8
8.I.48. Married, has one child. Does housework. No tenderness or undue fatigue. Occasionally slight low back pain. Back looks straight. No rib deformity. Slight prominence of right hip. Pelvis and shoulders level. Curve measures 35 degrees.

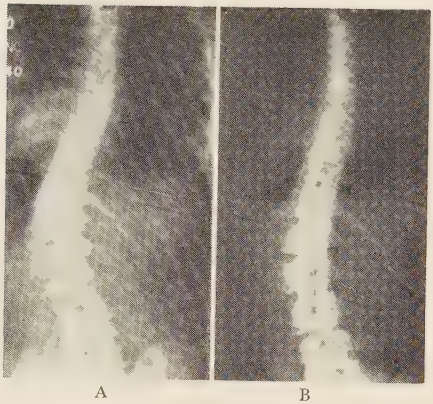


A 231183 B

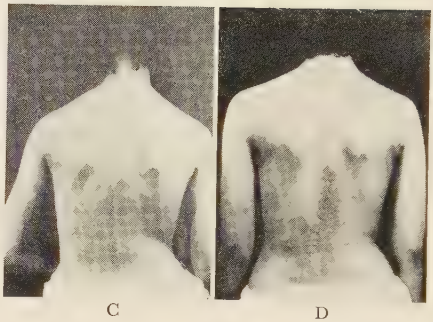
No. 231430 female born 9.II.25.
Left curve D_{11}–L_1–L_4, standing 61 degrees, lying 47 degrees, corrected to 17 degrees.
Spine fusion 15.IV.40 D_{10}–L_2
24. V.40 L_2–L_4
29.IX.45. No pain, undue fatigue or tenderness. Left shoulder elevated. Right posterior rib deformity. Pelvis level. Loss of correction to 26 degrees in six months. No further loss.



A 231430 B

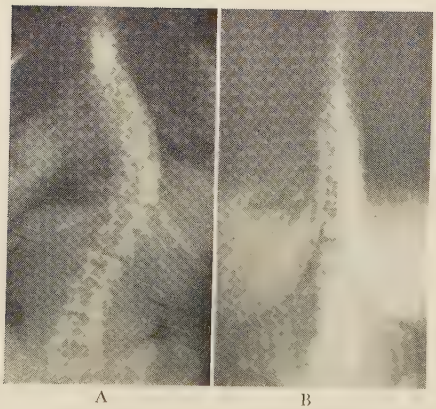


A B

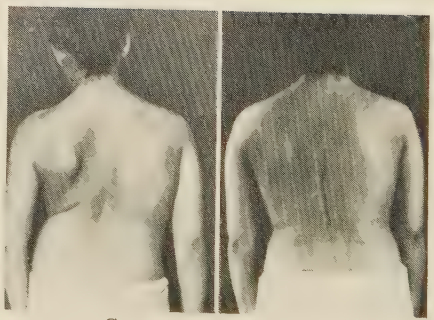


C D

No. 231513 female born 18.IX.28.
Left curve D_9–L_1–L_3, standing 27 degrees, lying 20 degrees, corrected to 0 degrees.
Spine fusion 28.II.41 D_9–L_3
9.III.48. Working full time, office work. No pain, undue fatigue or tenderness. Back looks straight. Shoulders level. Slight pelvic tilt to left and prominence of right hip. No rib deformity. Loss of correction to 15 degrees in six months. Curve measures now 17 degrees. The Roentgenograms are suggestive of pseudarthrosis at L_1–L_2.



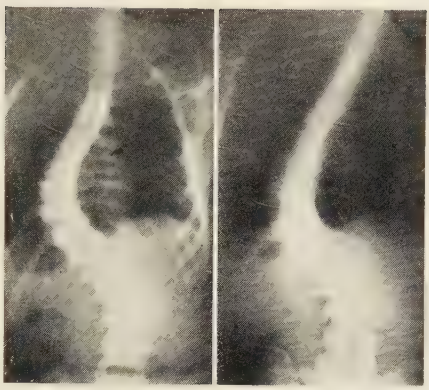
A B



C D

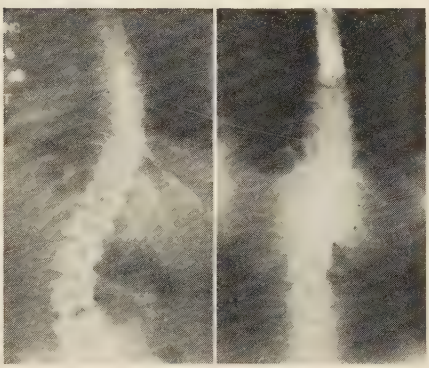
No. 231836 female born 8.III.27.
Right curve D_5–D_{10}–L_2, standing 39 degrees, lying 24 degrees, corrected to 4 degrees.
Spine fusion 29.IV.40 D_9–L_2
20. V.40 D_5–D_9
9.III.48. Office work eight hours a day. No pain, undue fatigue or tenderness. Back looks straight. Slight rib deformity. Pelvis and shoulders level. No hip prominence. Curve measures 6 degrees.

No. 233456 male born 9.IV.26.
Left curve D_7–D_{10}–D_{13}, standing 51 degrees, lying 46 degrees, corrected to 34 degrees.
Spine fusion 6.XI.40 D_9–D_{13}
27.XI.40 D_5–D_9 & D_{13}–L_1
9.III.48. Doing office work full time. No pain, undue fatigue or tenderness. Marked left dorsal curve, with considerable rib deformity. Shoulders and pelvis level. Some trunk shift to the left. Curve measures 47 degrees.



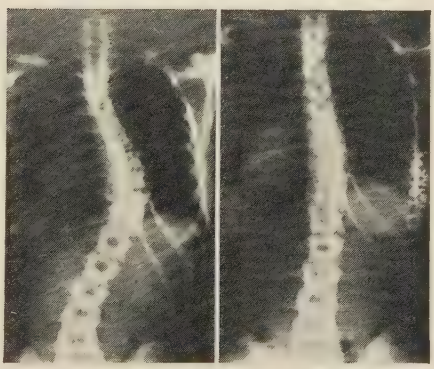
A 233456 B

No. 234805 female born 10.I.28.
Right curve D_5–D_8–D_{12}, standing 30 degrees, lying 22 degrees, corrected to 5 degrees.
Spine fusion 12.III.41 D_7–D_{11}
2.IV.41 D_5–D_7
2.IX.47. Normal activities. No pain, undue fatigue or tenderness. Back looks straight. Slight right rib deformity. Pelvis and shoulders level. Loss of correction to 12 degrees in six months. Curve measures now 14 degrees.



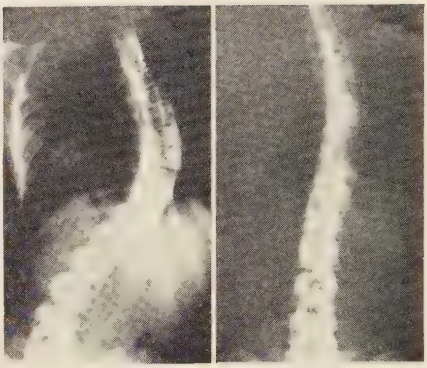
A 234805 B

No. 235276 female born 28.I.27.
Right curve D_6–D_9–L_1, standing 41 degrees, lying 29 degrees, corrected to 12 degrees.
Spine fusion 16. X.40 D_{10}–L_1
6.XI.40 D_5–D_{10}
19.III.48. Works for telephone company. No pain, undue fatigue or tenderness. Back looks straight. Hips and shoulders level. Slight right rib deformity. Curve measures 17 degrees.

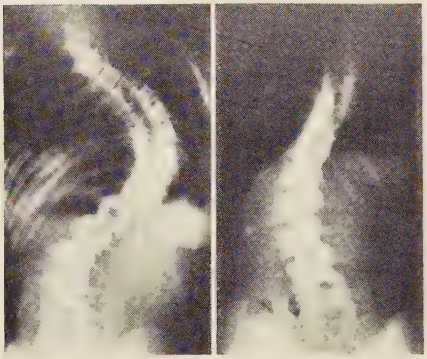


A 235276 B

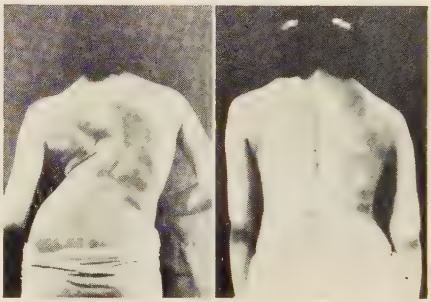
No. 235333 female born 11.VII.29.
Right curve D_5–D_9–L_1, standing 49 degrees, lying 41 degrees, corrected to 18 degrees.
Spine fusion 28. X.40 D_9 L_2
18.XI.40 D_4 D_9
19.III.48. Works as a secretary. No pain, undue fatigue or tenderness. Mild right curve with some rib deformity. Pelvis level. Right shoulder elevated. Curve measures 26 degrees.



A 235333 B

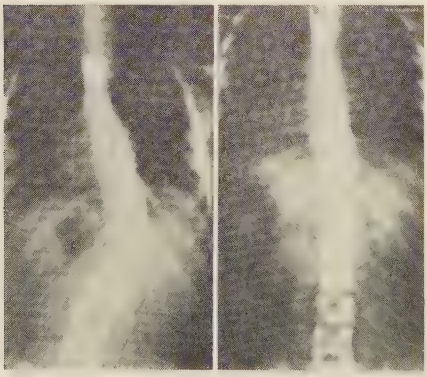


A B

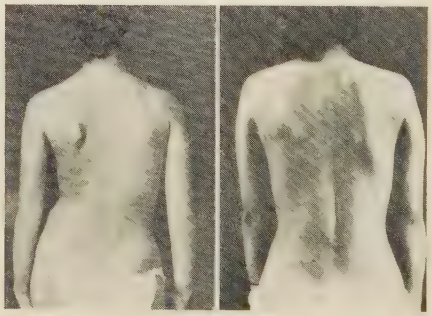


C D

No. 235720 female born 19.IV.28.
Right curve D_5–D_9–L_1, standing 75 degrees, lying 71 degrees, corrected to 40 degrees.
Spine fusion 24.III.41 D_9–L_1
21.IV.41 D_4–D_9
9.III.48. Doing office work eight hours a day. No pain, undue fatigue or tenderness. Moderate right curve with some right rib deformity. Shoulders and pelvis level. Right hip prominent. Loss of correction to 45 degrees.

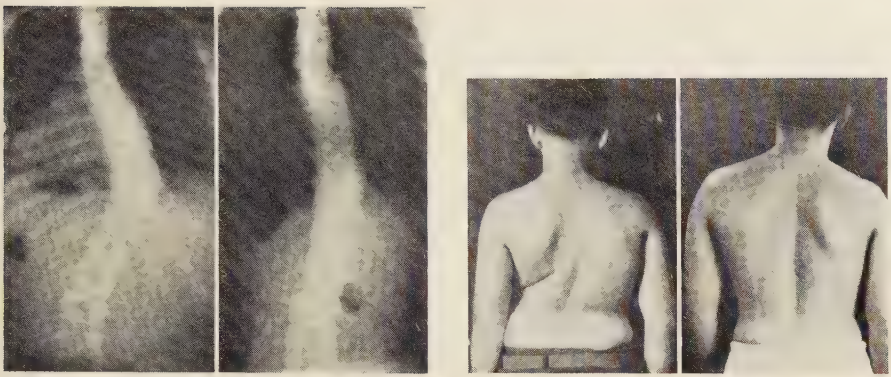


A B



C D

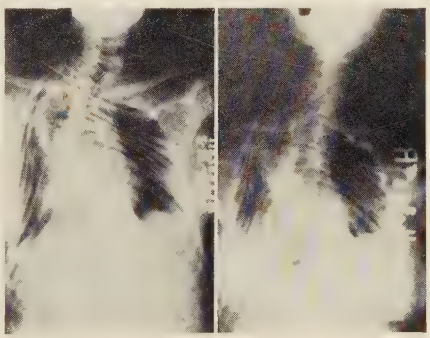
No. 236110 female born 5.VII.27.
Right curve D_7–D_{11}–L_2, standing 30 degrees, lying 22 degrees, corrected to 6 degrees.
Spine fusion 14. X.40 D_{11}–L_2
4.XI.40 D_7–D_{11}
28.X.48. Normal activities. No pain, undue fatigue or tenderness. Back is straight. No deformity. Pelvis and shoulders level. No hip prominence. No loss of correction.



A B C D

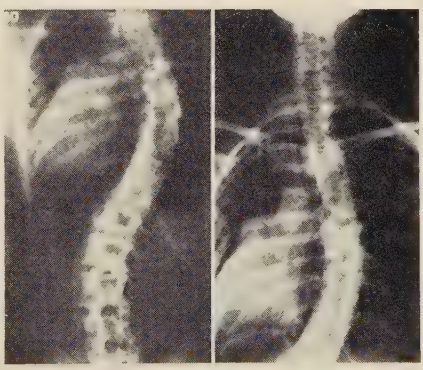
No. 236761 male born 4.II.27.
Right curve D_7–D_{10}–L_1, standing 37 degrees, lying 27 degrees, corrected to 8 degrees.
Spine fusion 9.XII.40 D_9–L_1
3. I.41 D_5–D_9
30.III.48. Active in sports, boxing, wrestling. No pain, undue fatigue or tenderness. Back looks straight. No rib deformity. Pelvis level. No hip prominence. Left shoulder slightly elevated. Curve measures 22 degrees.

No. 237525 female born 25.I.28.
Left curve D_2–D_5–D_8, standing 73 degrees, lying 70 degrees. No correction attempted.
Spine fusion 18. II.42 D_1–D_5
11.III.42 D_5–D_7
6.IV.48. Doing office work full time. Active in sports, tennis, swimming. No pain, undue fatigue or tenderness. Marked left curve with considerable rib deformity. Left shoulder elevated. Head tilted to right. Left hip prominent. Pelvis level. Curve measured 68 degrees 3.XI.47.



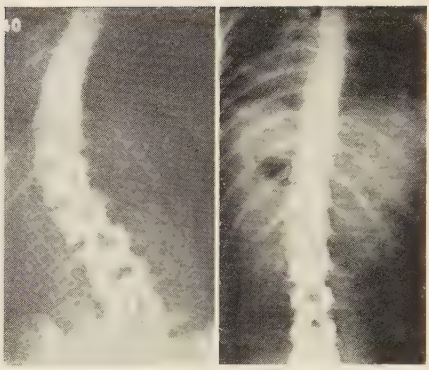
A 237525 B

No. 238043 female born 14.VIII.21.
Right curve D_5–D_9–D_{12}, standing 37 degrees, lying 30 degrees, corrected to 14 degrees.
Spine fusion 24. II.41 D_8–D_{12}
17.III.41 D_4–D_8
8.I.48. Married. Normal activities. No pain, undue fatigue or tenderness. Mild rib deformity. Pelvis and shoulders level. Lost correction to 26 degrees in one year, no further loss. Curve measures now 27 degrees.



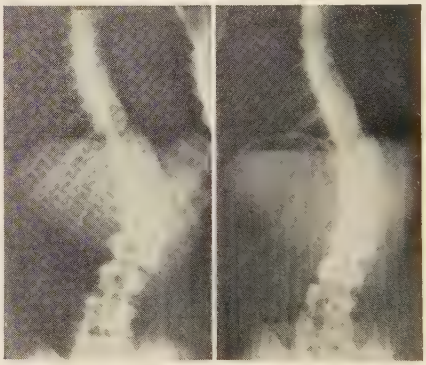
A 238043 B

No. 238713 female born 6.IX.25.
Left curve D_8–D_{12}–L_2, standing 33 degrees, lying 22 degrees, corrected to 9 degrees.
Spine fusion 9.I.42 D_{11}–L_2
30.I.42 D_8–D_{11}
Loss of correction in twelve months to 30 degrees.
24.II.43. Repair of pseudarthrosis between D_{10}–D_{11}, D_{11}–D_{12} and D_{12}–L_1.
Recorrected to 0 degrees before repair operation. In another six months loss of correction to 13 degrees.
Pseudarthrosis suspected at L_1–L_2.
25.VIII.43. Repair of pseudarthrosis.
Between D_{11}–D_{12} there was fibrous union with very little motion. Between D_{12}–L_1 there was a gap, one to three millimetres, filled with fibrous tissue and permitting considerable motion. Between L_1–L_2 a definite pseudarthrosis was present. D_8–D_{11} solid with mature hard bone.
8.IV.48. Doing office work. Active in sports. No pain, undue fatigue or tenderness. Back looks straight. Pelvis and shoulders level. No hip prominence. Curve measures 12 degrees.



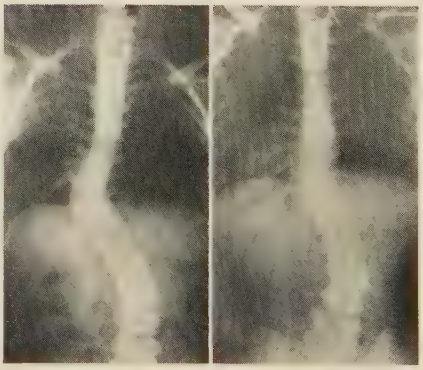
A 238713 B

No. 238838 female born 5.VII.21.
Right curve D_9–D_{12}–L_3, standing 38 degrees, corrected to 27 degrees.
Spine fusion 21.V.41 D_9–L_3
20.IV.46. No pain, undue fatigue or tenderness. Right dorso-lumbar area shows prominence. Left hip is prominent. Loss of correction to 34 degrees in nine months. No further loss.



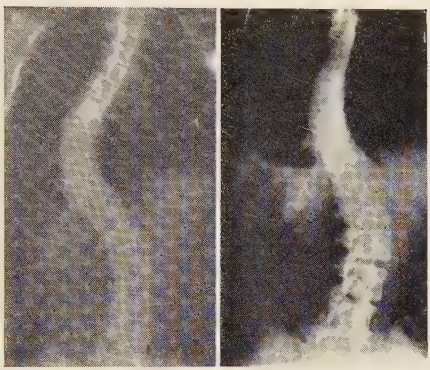
A 238838 B

No. 239771 female born 18.VI.28.
Left curve. D_{10} is a hemivertebra only the left half being present. D_7–D_{11}–L_1, standing 45 degrees, lying 45 degrees, corrected to 10 degrees.
Spine fusion 14. XI.41 D_{10}–L_1
8.XII.41 D_8–D_{10}
No motion was found between L_1 and L_2 as these joints had undergone spontaneous fusion. The joint on the left between D_{10} and D_{11} had been obliterated by fusion of the two laminae. Loss of correction to 35 degrees in three months. Four years later pseudarthrosis was detected.
16.IV.45. Repair of pseudarthrosis.
Pseudarthrosis was found at the level of D_{11} with motion easily demonstrated.
2.XII.47. Moderate left dorsal and right lumbar curves with some left rib deformity. Right hip prominent. Pelvis level. Fairly good balance.
Clinically, with increasing pain and acute tenderness at the D_{11} area, the likelihood of a fusion failure, despite X-ray report to the contrary, is great. Exploration of spine fusion advised. Curve measures 37 degrees.



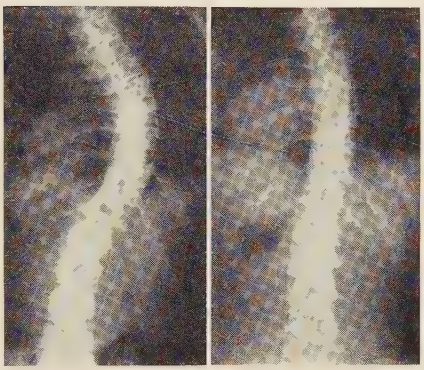
A 239771 B

No. A240 female born 15.IX.25.
Left curve D_6 D_9–D_{11}, standing 40 degrees, lying 33 degrees, corrected to 22 degrees.
Spine fusion 9.IV.41 D_8–D_{12}
23. V.41 D_4 D_8
20.V.48. Works as a secretary full time. No pain, undue fatigue or tenderness. Mild left curve with slight left rib deformity. Prominence of left hip. Lost correction to 30 degrees in nine months. No further loss.



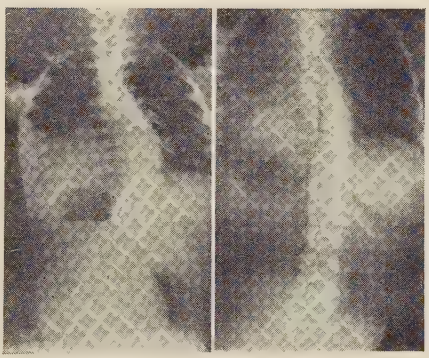
A A240 B

No. A2227 female born 13.IV.28.
Right curve D_5 D_9 D_{12}, standing 45 degrees, lying 39 degrees, corrected to 13 degrees.
Spine fusion 21. I.42 D_8–D_{12}
13.II.42 D_4–D_8
19.IV.48. Works as a receptionist. Engaged to be married. No pain, undue fatigue or tenderness. Back looks straight. Slight right rib deformity. Pelvis and shoulders level. Curve measures 18 degrees.



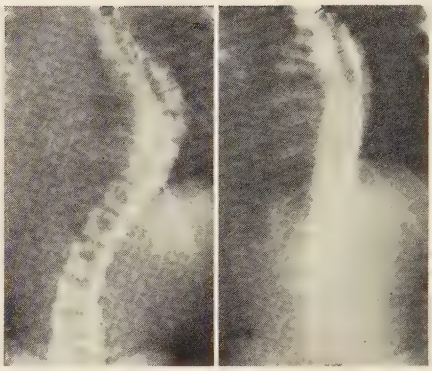
A A2227 B

No. A2832 female born 10.II.30.
Right curve D_5–D_9–L_1, standing 43 degrees, lying 24 degrees, corrected to 6 degrees.
Spine fusion 28. XI.41 D_9–L_1
19.XII.41 D_4–D_9
29.VI.48. In 1943 a spastic gait was noticed and the diagnosis of familiar spastic paraplegia made. Spasticity of lower extremeties increasing. No pain or tenderness. Mild right rib deformity and slight prominence of left hip. Pelvis and shoulders level. Loss of correction to 22 degrees in one year, no further loss.



A A2832 B

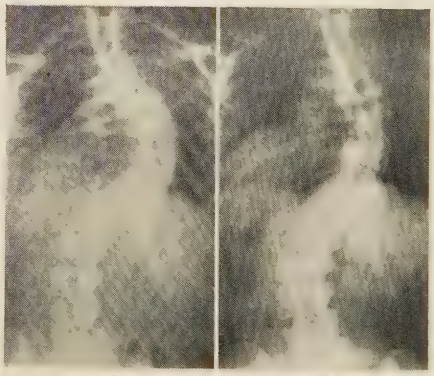
No. A4535 male born 19.II.27.
Right curve D_5–D_8–D_{12}, standing 62 degrees, lying 47 degrees, corrected to 30 degrees.
Spine fusion 1.XII.41 D_9–L_1
22.XII.41 D_1–D_9
11.III.48. Working full time as machine operator. No pain, undue fatigue or tenderness. Mild curve with some right rib deformity. Left shoulder slightly elevated. Pelvis level. No hip prominence. Curve measures 34 degrees.



A A4535 B

No. A4712 female born 23.VII.30.
1) Right dorsal curve D_4–D_8–D_{11}, standing 52 degrees,
2) Left dorso-lumbar D_{11}–L_3–L_5, standing 50 degrees,
corrected to 1) 22 degrees
2) 16 degrees
Spine fusion 10. IV.42 D_4–D_8
11. V.42 D_8–D_{11}
1.XII.43 D_{11} L_4
6.IV.48. Goes to school. Active in sports. No pain, undue fatigue or tenderness. Mild right curve. Practically no rib deformity. Pelvis and shoulders level. No hip prominence. Curves measure
1) 24 degrees
2) 15 degrees.

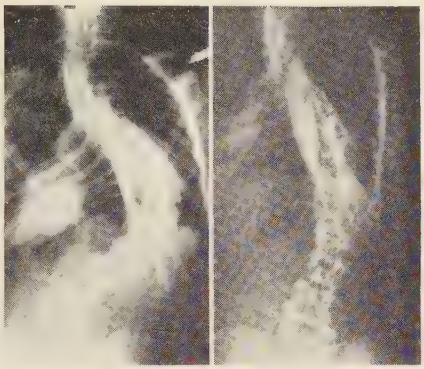
No. A5388 female born 10.X.27.
Right curve D_5–D_8–D_{12}, standing 65 degrees, lying 57 degrees, corrected to 38 degrees.
Spine fusion 23. I.42 D_9–L_1
13.II.42 D_4–D_9
19.IV.48. Works as a seemstress full time. No pain, undue fatigue or tenderness. Moderate right curve with considerable right rib deformity. Pelvis level. Left hip slightly prominent. Left shoulder elevated. Curve measures 44 degrees.



A A5388 B

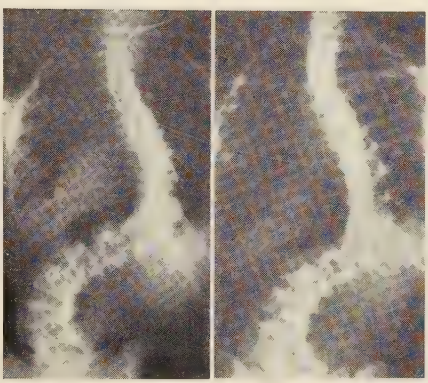
No. A5714 female born 13.VIII.28.
Right curve D_4–D_7–D_{11}, standing 31 degrees, lying 25 degrees, corrected to 17 degrees.
Spine fusion 6.III.42 D_8–D_{11}
27.III.42 D_4–D_8
6.IV.48. Working full time as a secretary. No pain, undue fatigue or tenderness. Mild right curve. Pelvis and shoulders level. No hip prominence. Loss of correction to 24 degrees in one year. No further loss.

No. A6431 female born 29.XII.26.
Right curve D_7-D_{11}-L_2, standing 74 degrees, corrected to 28 degrees.
Spine fusion 1.V.42 D_{10}–L_2
21.V.42 D_7–D_{10}
6.IV.48. Works in a bank full time. No pain, undue fatigue or tenderness. Moderate right curve with some right rib deformity. Left shoulder elevated, left hip prominent, slight pelvic tilt to the right. Lost correction to 35 degrees in one year.



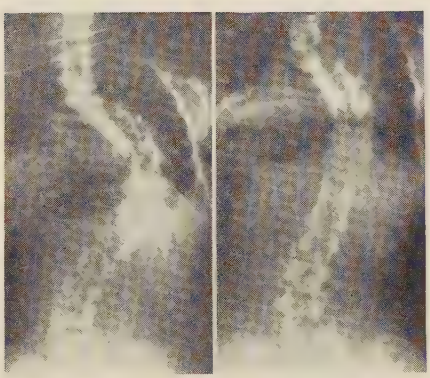
A A6431 B

No. A6850 female born 6.VIII.28.
Right curve D_6-D_9-D_{12}, standing 60 degrees, lying 52 degrees, corrected to 30 degrees.
Spine fusion 8.IV.42 D_6–D_{11}
6.IV.48. Leads a normal, active life. No pain, undue fatigue or tenderness. Considerable right dorsal curve with marked rib deformity. Left hip very prominent. Slight pelvic tilt to right. Shoulders approximately level. Curve measures 45 degrees.



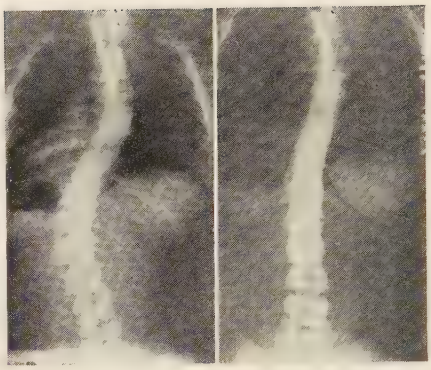
A A6850 B

No. A7149 female born 21.IX.29.
Right curve D_5-D_9–L_1, standing 68 degrees, lying 60 degrees, corrected to 42 degrees.
Spine fusion 26. I.42 D_9–L_1
25.II.42 D_4–D_9
15.IV.48. Works as a typist seven hours a day. No pain, undue fatigue or tenderness. Marked right curve, with considerable right rib deformity. Pelvis level. No hip prominence. Left shoulder slightly elevated. Loss of correction to 50 degrees in nine months. No further loss.



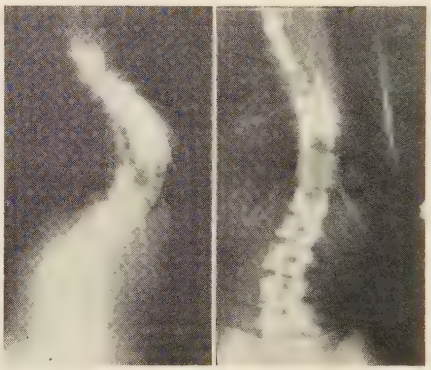
A A7149 B

No. A7152 female born 8.I.29.
Left curve D_9–D_{12}–L_3, standing 35 degrees, lying 23 degrees, corrected to 2 degrees.
Spine fusion 21. I.42 D_{11}–L_3
11.II.42 D_7–D_{11}
Loss of correction to 13 degrees in six months. Pseudarthrosis suspected at D_{12}–L_1.
31.VIII.42. Repair of pseudarthrosis.
There was a pseudarthrosis extending across the entire fusion at the level of D_{12}–L_1. Motion was great.
23.XI.48. Recently married. Until then doing secretarial work full time. No pain, undue fatigue or tenderness. Pelvis level. Right shoulder slightly elevated. Mild right curve and rib deformity. Curve measures 16 degrees.



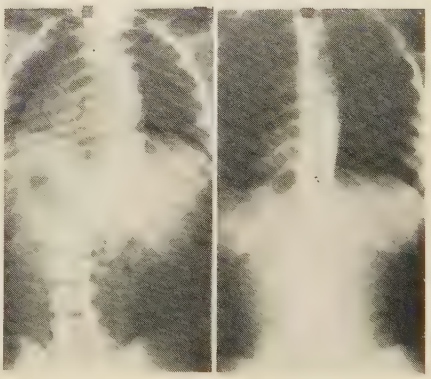
A A7152 B

No. A7707 female born 29.XI.25.
Right curve D_6–D_9–L_1, standing 63 degrees, lying 52 degrees, corrected to 25 degrees.
Spine fusion 11. II.42 D_9–L_1
6.III.42 D_5–D_9
1.IV.47. No pain, undue fatigue or tenderness. Slight right dorsal curve with mild rib deformity. Pelvis and shoulders level. No hip prominence. Loss of correction to 32 degrees in nine months. No further loss of correction.



A A7707 B

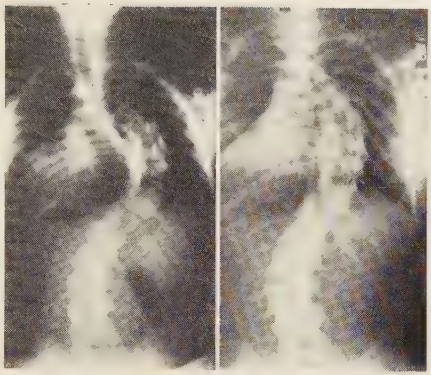
No. A7713 female born 10.II.29.
Right curve D_4–D_7–D_{11}, standing 50 degrees, lying 39 degrees, corrected to 15 degrees.
Spine fusion 26.XII.41 D_7–D_{11}
16. I.42 D_3–D_7
19.III.48. Works as a manager of a store. No pain, undue fatigue or tenderness. Back looks straight. No rib deformity. Pelvis and shoulders level. Right hip slightly prominent. Curve measures 22 degrees.



A A7713 B

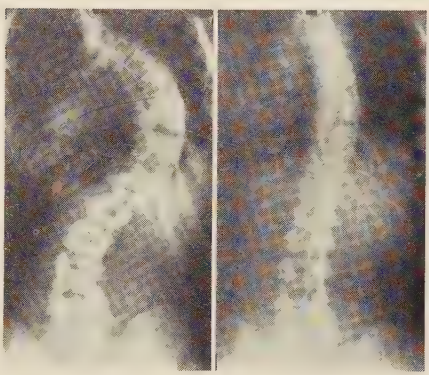
No. A10481 female born 12.II.25.
Left curve D_3–D_7–D_{10}, standing 47 degrees, corrected to 30 degrees.
Spine fusion 20. V.42 D_7–D_{11}
10.VI.42 D_3–D_7
17.XI.47. Normal activities. No pain, undue fatigue or tenderness. Mild left curve with some rib deformity. Right hip prominent. Curve measures 37 degrees.

No. A10622 female born 17.X.31.
Right curve D_4–D_9–L_1, standing 70 degrees, lying 67 degrees, corrected to 30 degrees.
Spine fusion 10. VI.42 D_8–L_1
1.VII.42 D_4–D_8
6.IV.48. Normal activities. No pain or undue fatigue. Slight tenderness of mid-fusion area. Moderate right curve with marked rib deformity. Pelvis and shoulders level. Slight prominence of left hip. Lost correction to 51 degrees in six months. Curve measures now 52 degrees.



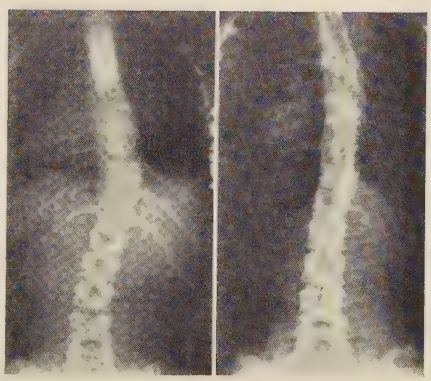
A A10622 B

No. A12788 female born 19.XI.29.
Right curve D_4–D_9–L_1, standing 52 degrees, lying 42 degrees, corrected to 16 degrees.
Spine fusion 2.XII.42 D_9–L_1
23.XII.42 D_5 D_9
18.XII.47. Normal activities. No pain, undue fatigue or tenderness. Mild right rib deformity. Pelvis and shoulders level. Curve measures 24 degrees.



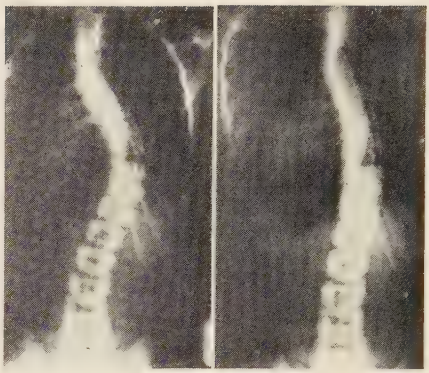
A A12788 B

No. A14013 female born 17.XI.31.
Right curve D_4–D_8 L_1, standing 38 degrees, lying 26 degrees, corrected to 9 degrees.
Spine fusion 30. XI.42 D_7–L_1
28.XII.42 D_4–D_7
Loss of correction in one year to 27 degrees. Pseudarthrosis was suspected at D_8 D_9.
14.II.44. Repair of pseudarthrosis.
Spine fusion L_1–L_2
A pseudarthrosis was found at the first vertebra at the upper end of the fusion. About at the apex of the fusion there was a transverse line which appeared as if it had previously been a pseudarthrosis, but later united with solid bone. Correction before repair operation to 23 degrees.
6.V.48. Goes to school. Active in sports. No pain, undue fatigue or tenderness. Back looks practically straight. Pelvis and shoulders level. Slight residual rib deformity. No hip prominence. Curve measures 24 degrees.



A A14013 B

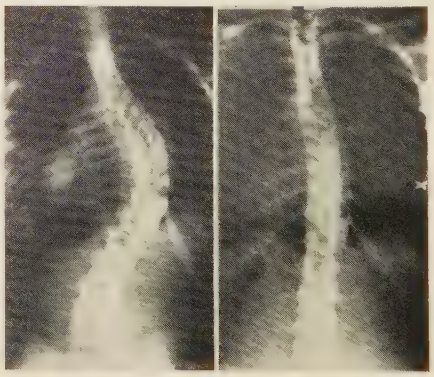
No. A14460 female born 16.VI.30.
Right curve D_6–D_9 D_{12}, standing 39 degrees, corrected to 23 degrees.
Spine fusion 30.XII.42 D_9 L_1
25. I.43 D_5 D_9
19.IV.48. Attends school. Active in sports. No pain, undue fatigue or tenderness. Moderate right curve with some rib deformity. Shoulders level. Slight right pelvic tilt. Left hip slightly prominent. Curve measures 25 degrees.



A A14460 B

No. A15046 female born 13.VIII.30.
Left curve D_{10}–L_1–L_3, standing 63 degrees, lying 45 degrees, corrected to 30 degrees.
Spine fusion 2.XII.42 D_{10}–L_3
In fourteen months loss of correction to 58 degrees, pseudarthrosis suspected at D_{11}–D_{12}.
1.V.44. Repair of pseudarthrosis.
Fusion L_3–L_4
The fusion mass appeared continuous and of good consistency except at D_{11}–D_{12} where there was fibrous union with motion easily demonstrated.
Recorrected before repair operation to 30 degrees.
6.IV.48. Goes to school. Participates in no sports. Complains of pain in the back and flanks, gets easily tired when standing, some tenderness of the lower part of the fusion area. Severe left curve with considerable rib deformity. Right hip prominent. Pelvis and shoulders level. Curve measures 60 degrees. (Fig. 31 A and D).

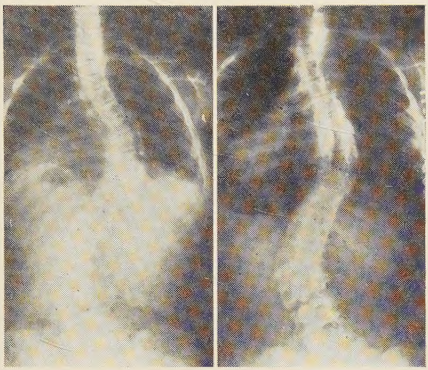
No. A15196 female born 13.VIII.29.
Right curve D_6–D_{10}–L_1, standing 43 degrees, lying 33 degrees, corrected to 13 degrees.
Spine fusion 27. XI.42 D_9–L_1
16.XII.42 D_5–D_9
8.IV.48. Doing office work. No pain, undue fatigue or tenderness. Back looks straight. Pelvis and shoulders level. No hip prominence. Curve measures 20 degrees.



A A15196 B

No. A15398 male born 10.XI.27.
Poliomyelitis in 1931.
Right curve D_4–D_8–D_{12}, standing 45 degrees, lying 37 degrees, corrected to 26 degrees.
Spine fusion 11. XI.42 D_8–D_{12}
4.XII.42 D_4–D_8
Loss of correction to 32 degrees in nine months.
23.VIII.43. Repair of pseudarthrosis.
Definite motion at D_{10}–D_{11}, questionable motion at D_9–D_{10}. No correction before repair of pseudarthrosis.
12.II.48. No pain, undue fatigue or tenderness. Good balance. Pelvis and shoulders level. Moderate rib deformity. Curve measures 35 degrees.

No. A16545 female born 13.XI.30.
Right curve D_6–D_9–D_{12}, standing 52 degrees, lying 44 degrees, corrected to 26 degrees.
Spine fusion 28.XII.42 D_9–L_1
1. II.43 D_5–D_9
Loss of correction in fourteen months to 45 degrees.
29.V.44. Repair of pseudarthrosis.
Fusion of L_1–L_2
Pseudarthrosis with definite motion was found at the level of D_9–D_{10}. Cartilage was present in both facets at this level. The rest of the fusion plate was solid. Corrected before repair of pseudarthrosis to 37 degrees.
19.IV.48. Attends school. Active in all kinds of sport. No pain, undue fatigue or tenderness. Pelvis and shoulders level. Right hip slightly prominent. Mild posterior rib deformity. Slight flattening of the dorsal kyphosis. Curve measures 42 degrees.



A A16545 B

VALD. PEDERSENS BOGTRYKKERI
KØBENHAVN